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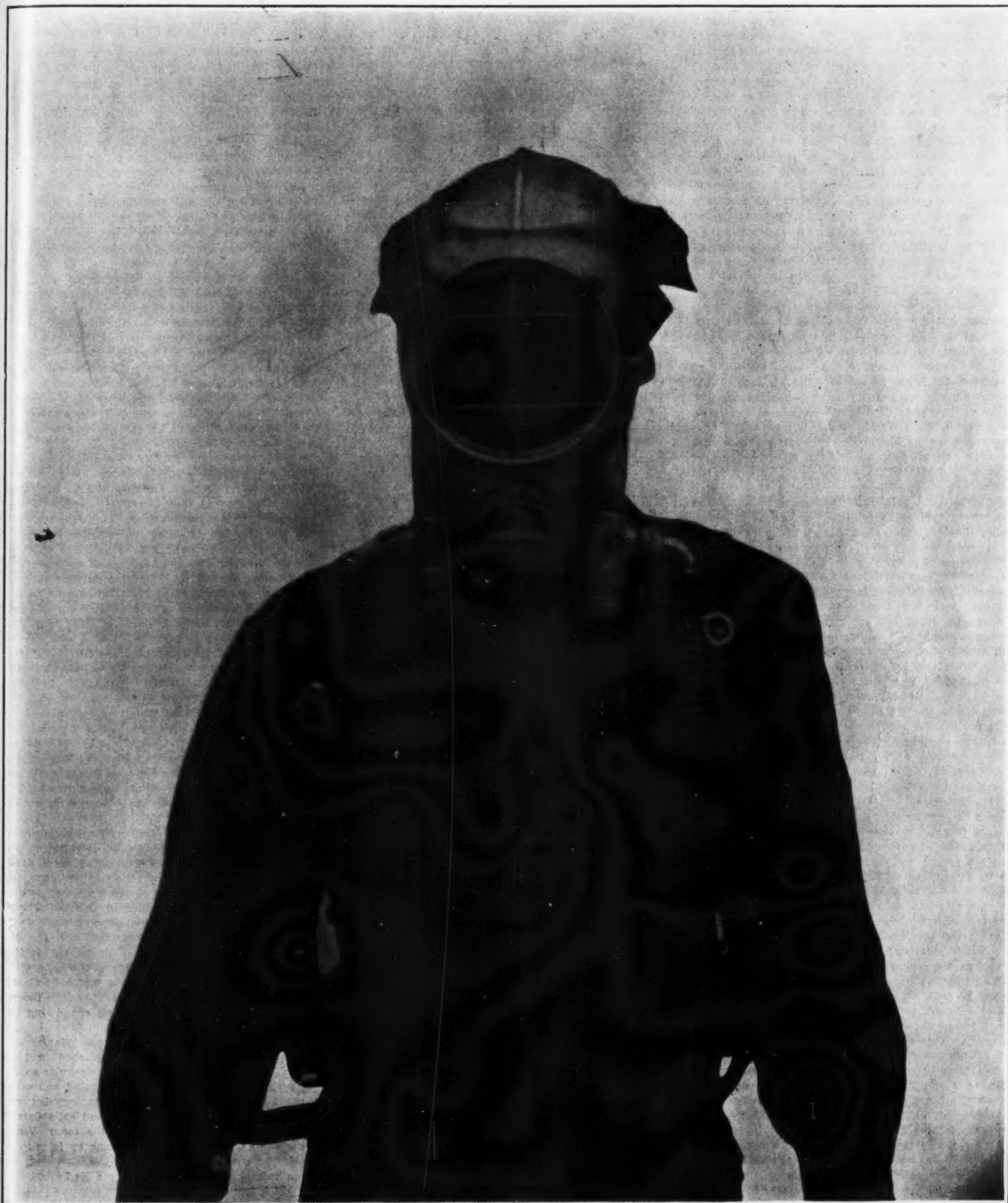
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THIS MAN IS NOT A DIVER. HE IS A MINER, WHOSE HEAD IS INCASED IN AN OXYGEN HELMET SO THAT HE MAY FIGHT HIS WAY THROUGH POISONOUS GASES AND RESCUE ASPHYXIATED COMRADES

SAVING HUMAN LIFE IN MINES.—[SEE PAGE 264.]

# The Discovery of Kepler's Laws

## An Epoch-making Astronomical Achievement

ALMOST exactly three centuries have passed since the discovery of the laws of planetary motion. In 1609 Kepler announced that the orbit of Mars is an ellipse, having the sun in one of its foci. The simple and ingenious empirical process which led Kepler inevitably to the discovery of the true form of the orbit is not generally known. This process is described by Prof. Bigourdan of the Observatory of Paris in an article in *Revue des Sciences*, which may be summarized as follows:

### I. THE FIRST LAW.

In the year 1600 Kepler went to Prague to assist Tycho Brahe in the construction of his new Rudolphine tables of the planets. The two great astronomers soon fell into discord, for Tycho believed that the sun revolved about the earth, while Kepler adopted the Copernican theory of a central sun. Moreover, Tycho was haughty and arrogant and Kepler was ill-paid and irritable. A complete rupture was averted by the sudden death of Tycho in 1601. Kepler succeeded Tycho as astronomer royal, and Tycho's accumulated treasure of observations was placed at his disposal. Kepler continued to occupy himself with the planets and particularly with the intractable planet Mars, asserting that the secret of planetary motion must be learned from Mars or remain forever unknown. In 1609, after nine years of patient research, he published his work, "De Stella Martis," in which he proclaimed the elliptical form of the orbit of Mars.

For 2,000 years the Pythagorean theory of exactly circular planetary orbits had been admitted without argument, but the earth was not placed at the center of the circle. For example, those astronomers who believed that the sun *S* revolved about the earth *T* (Fig. 1), placed the center *C* of the solar orbit at a distance *CT* from the earth. This distance, called the eccentricity, accounted for the observed unequal motion in longitude of the sun, conceived as moving uniformly in its circular orbit. A planet was supposed to move in its circular orbit, not uniformly, but with uniform angular velocity, about a *punctum aequantis* *E*, symmetrical with *T* with respect to the center *C*.

Kepler attempted in vain to represent the motion of Mars on this hypothesis. He succeeded in reproducing the longitudes observed by Tycho Brahe, but the latitudes were in error, in some cases by as much as 9 minutes of arc.

Kepler then made trial of a theory of planets, including the earth, revolving about a fixed sun. This new hypothesis introduced a new difficulty, for if the observations are made from a moving earth it is necessary, first of all, to determine the earth's motion with accuracy. This problem, very similar to that of the determination of the orbit of Mars, was attacked by a method whose simplicity attests Kepler's genius.

In Fig. 2, let *T*, *T*<sub>1</sub>, *T*<sub>2</sub> represent three positions of the earth in the unknown orbit which it describes about the fixed sun *S*, and let *M* denote another fixed point, whose heliocentric coordinates are known. From these coordinates the angles *MST*, *MST*<sub>1</sub>, *MST*<sub>2</sub> can be deduced, while the angles *MT*<sub>1</sub>*S*, *MT*<sub>2</sub>*S*, *MT*<sub>3</sub>*S* can be determined by observation. Hence, all the angles of the triangles *MST*, *MST*<sub>1</sub>, *MST*<sub>2</sub> can be determined, and, as these triangles have a common side *MS*, the relative lengths of the radii vectors *ST*, *ST*<sub>1</sub>, *ST*<sub>2</sub> can be found. By repeating this process for various positions of the earth the form of the earth's orbit can be determined.

The point *M* may be any one of the planets. If the planet's period of revolution is accurately known and its position in the heavens is observed at intervals exactly equal to multiples of this period, the planet represents a fixed point, so far as these observations are concerned.

The periodic times of the planets have been known pretty accurately since the days of Hipparchus. Kepler selected, to represent the fixed point *M*, the planet Mars, whose orbit was the ultimate object of his study. This enabled him to reverse the problem and calculate *SM*, the radius vector of Mars, after he had constructed his tables of the earth's motion.

Among Tycho Brahe's observations of Mars, which formed the basis of Kepler's work, there was little probability of finding even a few separated by exact multiples of the period of revolution, but it was only necessary that this condition should be satisfied approximately, as the observations could be reduced to the exact epochs required by the application of small corrections, which could be calculated without sensible error.

Kepler formed his tables of the earth's motion on the theory of a circular orbit and a *punctum aequantis*. From these tables he could compute the earth's radius

vector *ST* at any epoch, and could thence deduce the radius vector of Mars *SM*. He then tried to represent the observed positions of Mars by means of a circular orbit about an eccentrically placed sun. Three values of the radius vector, together with the values of the heliocentric longitude for the same epochs, supplied data for computing the three elements of the orbit of Mars: the radius, the eccentricity and the position of the line of apsides.

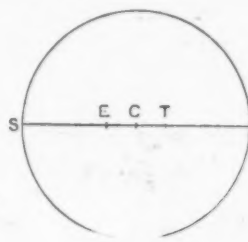


Fig. 1

These elements were already known approximately, and Kepler's results differed considerably from the known values. Furthermore, different groups of three positions gave different values of the elements. But Kepler was unwilling to abandon the old theory of a circular orbit without additional evidence.

From Tycho's observations and the old tables he determined the heliocentric longitudes of Mars at aphelion and perihelion. Then, by the empirical method indicated above, he calculated the values of the radius vector at the same epochs, i. e., the two segments of the line of apsides. Finally he assumed that the unknown orbit was symmetrically divided by that line. From these data he could calculate the radius vector at any epoch and compare it with the value obtained by the empirical method. He found

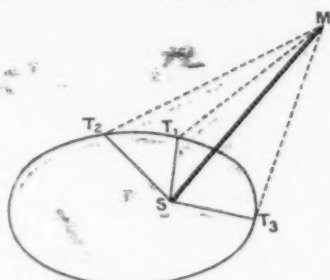


Fig. 2

that the value calculated on the theory of a circular orbit was always greater than the real or empirical value.

Kepler then definitely announced that the orbit was not circular. He at first rejected the ellipse in favor of the egg-shaped oval, but this curve likewise failed to stand the test which had eliminated the circle. At last, after long perplexity, in which he complained that his theory had gone up in smoke, and that the problem would drive him mad, he found that the despised ellipse stood the test and announced that the orbit of Mars is an ellipse having the sun in one of its foci. This is a particular case of Kepler's First

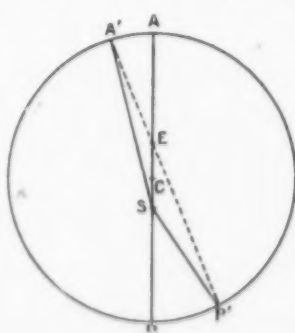


Fig. 3

Law, which he subsequently extended to all of the planets.

### II. KEPLER'S SECOND LAW.

The law of the conservation of areas, which states that the radius vector of a planet describes equal areas in equal times, evidently applies to uniform motion in a circle. Kepler saw that this law also applies, very approximately, at and near the aphelion

with uniform velocity about a *punctum aequantis* *E* (Fig. 3), placed opposite the sun *S*, and equidistant with it from the center of the circle *C*. In the figure *AA'* and *PP'* represent arcs described, in equal short intervals of time, from the aphelion *A* and the perihelion *P*. *A'*, *E* and *P'* lie in the same straight line, by the hypothesis of uniform angular velocity about *E*. The areas described by the radius vector in the two equal intervals are *ASA'* and *PSP'*. Owing to the symmetrical position of *E* and *S*, with respect to *C*, *AE* = *PS*, and *AS* = *PE*. Hence

$$\frac{ASA'}{PSP'} = \frac{\frac{1}{2}AS \times AA'}{\frac{1}{2}PS \times PP'} = \frac{AS}{PS} \times \frac{AE}{PE} = \frac{AS}{PS} \times \frac{PS}{AS} = 1.$$

Having established this much, Kepler felt a moral certainty that the law of areas applied also to the ellipse, but he could not find a satisfactory demonstration of this fact until some years later.

Kepler's dedication of "De Stella Martis" to the Emperor Rudolph II., containing a poetical appeal for means to extend his researches to the other planets, is worth quoting in the following condensed form, as an illustration of the writer's imagery and the spirit of the times:

"I bring Your Majesty a noble prisoner, the fruit of a laborious and difficult war. It is not the first time he has been a captive, for long ago the terrible god of war was caught in Vulcan's net. Hitherto he has triumphed over all human devices. In vain have the astronomers employed every resource and put all their troops into the field. Mars, mocking their efforts, has shattered their engines and their hopes, retrenched himself in his impenetrable domain and concealed his movements from their spies. The valiant Captain Tycho Brahe has studied the enemy's mysterious movements almost nightly during twenty years, and has bequeathed his observations to me. In the course of the war our camp has been desolated by death, pestilence and sedition. Many soldiers deserted and were replaced by raw recruits, and even the rations ran short.

"At last the enemy sent his capitulation by the hand of his mother, Nature. He gave his parole and Arithmetic and Geometry escorted him to our camp. He has since proved that his parole can be trusted and he asks but one favor from Your Majesty. His father Jupiter, his grandfather Saturn, his brother Mercury and his sister Venus are still in the sky. He pines for their society and longs to see them also enjoying your hospitality. For this purpose the war must be prosecuted with vigor; but money is the sinews of war, wherefore I beseech Your Majesty for the funds required for the levy of fresh troops."

### III. KEPLER'S THIRD LAW.

The Third Law was not discovered until 1618, after twenty-two years of research and speculation. In the "Mysterium Cosmographicum," published in 1596, Kepler writes:

"I propose to show that God, in creating the universe and arranging the spheres, had in view the five regular solids of geometry, and fixed by their dimensions the number, proportions and motions of the spheres. Take the sphere of the earth as a unit and circumscribe it with a regular dodecahedron. The sphere that contains this dodecahedron is the sphere of Mars."

The spheres of Mars and Jupiter, Kepler continues, are similarly related to a regular tetrahedron described about the former and within the latter, those of Jupiter and Saturn to a cube, those of Venus and the earth to an icosahedron and those of Mercury and Venus to an octahedron. Kepler in this early work compares the distances of the planets from the sun derived from this geometrical system, with the distances given by Copernicus, and finds that Jupiter alone presents a serious discrepancy, which he attributes to the inaccuracy of the value given by Copernicus. Kepler was satisfied with the result, although he could not then find a simple law connecting the distances of the planets.

He returns to the subject in the "Harmonices Mundi," a work in five volumes, published in 1619, in which he discusses polygons, the five regular solids, astrology, politics, the faculties of the mind and other things. He revives the Pythagorean analogy between music and the harmony of spheres, and calls Saturn and Jupiter the bass voices, Mars the tenor, Venus the contralto and Mercury the soprano or falsetto of the celestial choir.

From this chaos of dreams emerges Kepler's Third Law, which is thus formulated:

"The proportion between the periodic times of two planets is exactly equal to the sesquialterate ratio of the mean distances of the planets from the sun."

other words, the squares of the periodic times are proportional to the cubes of the mean distances, as the Third Law is usually expressed. Contrary to his wont, Kepler does not give the history of this discovery, but the work terminates with the following famous passage:

"Eight months ago I saw the first ray of light; three months ago I saw the dawn; three days ago

I saw the sun in his splendor. I give myself up to enthusiasm. I voluntarily defy mankind with the ingenious confession that I have stolen the golden vase of the Egyptians to make of it a tabernacle to my God, far from the bounds of Egypt. If you pardon me I shall rejoice, if you reproach me I shall endure it. The die is cast. I have written my book. It will be read by the present generation or by posterity,

it matters not. It can await its reader. Has not God waited six thousand years for a contemplator of his works?" He concludes with a prayer of thanksgiving to the Creator.

Thus were established Kepler's three laws of planetary motion, which led Newton to the conception of universal gravitation, the basis of modern astronomy.

## Preparation of Pure Radium Salts\*

### The Process of Fractionation Employed

By Madame Curie

To EFFECT the separation of pure radium chloride from the barium chloride with which it is associated, I have subjected the mixed chlorides to a fractional crystallization first from pure water, and then from water acidulated with hydrochloric acid. This process is based upon the fact that radium chloride is less soluble than barium chloride.

A saturated solution of the chlorides in pure distilled water at boiling temperature is prepared, and is left to crystallize in a covered vessel. After cooling, a deposit of fine crystals is found upon the bottom of the crystallizing vessel, and the supernatant solution can be readily poured off. If a sample of the mother liquor is evaporated to dryness, and the residues tested, it is found to be five times less active than the portion originally crystallized out. In this way, the chlorides are separated into two portions, A and B, or which A is much more active than B. The operation is now repeated with each of these parts, thus again obtaining from each a further crop of two parts. The less active portion obtained from A is then united with the more active portion obtained from B, these two portions having approximately the same activity. The result of this step is three fractions, which are once more subjected to the operation described. The number of fractions thus prepared is not allowed to increase indefinitely, for, as the process goes on, the activity of the soluble portion becomes less and less. When it has sunk to an insignificant value, the particular portion is eliminated from the process. After a suitable number of fractionations, the most difficultly soluble portion, which is richest in radium, is also withdrawn from the operation.

A fixed number of fractions is maintained. After a series of crystallization the saturated solution of one fraction is united with the crystals of the next following fraction. When, however, the most readily soluble fraction is discarded at the end of a series, a new readily soluble fraction is prepared in the next series, and the most active crop of crystals is taken out of the process. By systematically following out this scheme, a very regular mechanism of fractionation is obtained, the number of fractions, and the activity of each fraction, remaining constant, each being about five times as active as the next lower in order. At the one end an almost inactive product is discarded and at the other end a chloride enriched in radium is collected. The total quantity of material diminishes continually, and the several fractions become smaller and smaller as their activity increases. The work is begun with six fractions, and the activity of the chloride discarded at the end is only one-tenth that of uranium.

The accompanying diagram represents the scheme of such a fractionation. Each point represents a crop of crystals from the portion indicated by the affixed numeral. The two arrows extending from a given point indicate the two products, crystals and mother liquor, resulting from each crystallization, e. g., to the left, crystal, to the right, mother liquor. Where two arrows converge to a point, this indicates the union of the crystals separating from one portion with the solution from the immediately preceding portion. The outwardly directed arrows signify that the final product has been removed from the fractionating process.

When a large proportion of the inactive substance has been in this way eliminated, and the quantity of material has consequently been much reduced, it is no longer worth while to separate out these portions at such low activity. The last members in the series are then discarded, and are replaced from above by previously collected active chloride, with the effect that a chloride richer in radium is precipitated than at first. This is continued until the crystal crops at the beginning of the series represent pure radium chloride. If the fractionation has been carried out perfectly, the amount of intermediate products left over will be very small.

When, in the course of the fractionation, the bulk of the individual fractions has been much reduced

the separation by crystallization becomes less effective, because the solutions cool off too rapidly, and the volume of the mother liquor decanted off becomes too small. At this stage it is advantageous to add a definite amount of hydrochloric acid to the water used for dissolving, gradually increasing the amount of acid so added, as the fractionation proceeds. This addition has the advantage that the volume of the solution is thereby increased, owing to the fact that the chlorides are less soluble in dilute hydrochloric acid than in pure water. At the same time, the fractionation becomes more thorough, the difference between the fractions separated from a given stock is increased. If the acid is added in considerable concentration a very excellent separation is obtained, and the fractionations may be reduced to three or four. It is therefore a great advantage to begin with the addition of hydrochloric acid just as soon as the diminished amount of material permits this step to be taken without inconvenience.

The crystals which separate out from strongly acid solutions are long and needle-shaped, and identical in appearance, whether they be barium chloride or radium chloride. Both these are doubly refractive. The crystals of the barium chloride containing radium are colorless; if, however, the radium content reaches a certain limit, the crystals assume, after standing for several hours, a yellow color, ranging toward orange, or sometimes a fine rose tint. This color dis-

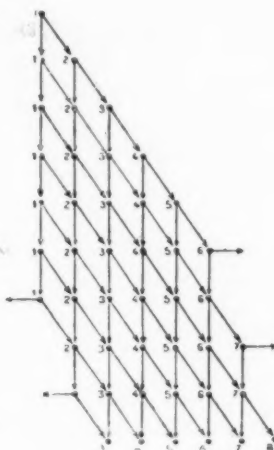


DIAGRAM INDICATING THE SCHEME OF SUCCESSIVE FRACTIONAL PRECIPITATIONS

appears on dissolution. The crystals of pure radium chloride do not become colored in this way, or at least not as rapidly, so that the coloration appears to be dependent upon the simultaneous presence of radium and barium. The maximum coloration occurs when the amount of radium assumes a certain definite proportion, and this furnishes a means of gaging the progress of the fractionation. So long as the most active fraction becomes colored, we know that it still contains a considerable amount of barium; if it no longer becomes colored on standing, while the fractions of lower order do, then the colorless portion is approximately pure radium chloride.

I have sometimes observed crops of crystals which consisted partly of colorless crystals, and partly of others, which became colored upon standing. Perhaps they might have been separated by picking them out individually, but this was not attempted.

Toward the end of the fractionation the successive fractions no longer display the same relative activity, nor is the proportion of their activity as regular as at the beginning of the process; this, however, does not cause any serious disturbance in the progress of the fractionation.

In working up a few kilograms of the chlorides obtained from a ton or more of the residues used as raw material, the amount of intermediate products left over

ing ninety per cent of the barium salt, a product enriched in radium can be delivered from the factory. This first fractionation requires comparatively large volumes of the saturated solutions and is carried out in cast-iron kettles. In place of distilled water rain water or river water as poor in dissolved salts as possible, is used, from which all sulphates have been carefully precipitated by the addition of a small excess of barium chloride.

The separation of radium can also be carried out by the fractional precipitation with alcohol of an aqueous solution of the barium chloride containing radium. I used this method at first, but subsequently abandoned it in favor of the one described above, which assures greater uniformity. At times, however, I have made use of the precipitation by alcohol, to purify radium chloride containing a small amount of barium chloride admixed with it. The latter remains dissolved in the slightly diluted alcohol, and can be thus removed.

Giesel, who has been occupied with the preparation of radioactive bodies since the publication of our first investigations, recommends for the separation of barium and radium the fractional crystallization of the mixed bromides from an aqueous solution. I have found that this method is very advantageous, especially at the beginning of the fractionation. This, however, is the case only if the amount of salts to be fractionated is not too large. If there are several kilograms to be treated, the use of a corresponding amount of hydrobromic acid becomes objectionable, partly on account of its high price, and also because the cast-iron kettles are more easily attacked by the bromides than by the chlorides. Nevertheless, it is advantageous to convert into bromides the chlorides obtained from the first fractionation as carried out in the factory, which are greatly reduced in bulk as compared with the original raw material. In this way, a more rapid fractionation is secured, so long as the quantity of material is not too greatly reduced. When, however, the amount of the salt is quite small, working with the bromides is less satisfactory than with the chlorides, owing to the fact that the former are on the one hand much more soluble, and on the other hand much more subject to change than the latter. A solution of the bromide very rich in radium, in water or dilute hydrobromic acid, undergoes very rapid alteration with liberation of bromine. For this reason it is, in my opinion, advantageous to convert salts of high radium content into chlorides in preparing a pure and stable radium salt. In the dry state, the chloride is more sharply defined and more stable than the bromide, and does not undergo any appreciable spontaneous change.

Whatever process of fractionation is employed, it is always useful to control the course of the process by measuring the activity of the product.

It should be emphasized that a radium compound which has been prepared in the solid form, either by crystallizing or precipitating from a solution, does not have a constant activity from the start. The activity increases for about one month to a limiting value which thereafter remains constant. The final activity is five or six times as great as the initial activity. These changes must be taken into account in measuring activity. The final activity is more clearly defined, but in the course of chemical operations upon radium salts, it is more practical to measure the initial activity of the solid product.

While the salt submitted to fractionation has, of course, always undergone a previous purification, it is nevertheless often desirable to purify once more a salt of high radium content. The fractionation itself of course effects a certain purification, inasmuch as traces of the salts which are very readily soluble in acidulated water (e. g., those of calcium, iron and magnesium, etc.) are eliminated. On the other hand, however, traces of lead chloride or bromide accumulate with the radium salt in the difficultly soluble portions. For this reason, it is generally speaking, not advisable to use a salt of merely moderate radium content for the purpose of preparing a pure radium salt.

# Psychanalysis

Getting at the Facts of Mental Life

A New Field of Research

PSYCHANALYSIS is a new word, which, in terms comprehensible to the lay mind, has been defined, says *Science and Discovery*, as the science of reading the inmost secrets of the heart and soul in spite of—sometimes without the least suspicion on the part of—the person who is the subject of investigation. The word psychanalysis has been much used in the medical and psychological organs of late with reference to the remarkable discoveries in pathology of mental ills by the distinguished Dr. Freud of Vienna. But the practical application of psychanalysis as a means of getting at the facts of mental life is most indebted to Dr. Jung, the famed specialist in psychological therapeutics whose cures are making a sensation in Germany. It has been said of him in the *London Lancet* that his cases read like reports from a new psychological world. The fullest account of the Jung method is given by the able associate in psychiatry at Columbia University, Dr. E. W. Scripture. There are three methods of getting at the facts of mental life, explains Dr. Scripture. The first is that of simple observation. This leads to treatment by the physician by the usual medical procedure. The second method of getting at the facts of mental life is by that of experimental psychology. Its aim is a most careful and accurate analysis of a patient's mental condition by tests and records. This has been much exploited in lay and technical publications in late years. The third method—involving medical reports from a quiet new psychological world—is that of psychanalysis.

To take up Dr. Scripture's exposition, suppose a patient presents himself with a paresis of the right arm which began years ago. There is not the slightest symptom of anything organically wrong. It is evidently a hysterical paralysis. Or suppose a man appears complaining that he is tortured beyond endurance by a fear that he can not perspire. He never has the slightest difficulty and he knows the fear to be foolish. Yet this fear is so constant and overpowering that he has been obliged to give up work. Again a patient comes to the office saying that for years he has been tortured by a fear of touching filth. He washes his hands a hundred times a day.

Such cases are beyond the methods of observation. In our own mental life there is nothing like such conditions. They are so far beyond our understanding that they seem weird or incomprehensible. The patient with the fear of filth told Dr. Scripture that he knew it to be nonsensical and that he spent hours in discussing it with himself. It is one of the greatest feats of the method of psychanalysis that it has found the mental mechanism of such cases.

To analyze a case of the sort, recourse is had by Dr. Jung to his co-called association method. In this a word is spoken and the patient is required to say at once what he first thought of. The time taken is measured with a stop-watch. After a hundred such associations the patient is required to tell again what he thought of in each case. Whenever the time of association is unusually long, when there is evidence of forgetfulness, when the patient does not respond at all to the word called out, when his association is superficial—in short whenever the association is of unusual character—the word called out touched upon some topic on which the person was highly sensitive. A sensitive topic in one case was an experience on the water and a record of it works out in this style:

Word Spoken	Association	Time	Memory	Sensitive Topic or Complex
head	hair	1.4	x	
green	meadow	1.6	x	
water	deep	5.0	swim	!
stick	knife	1.6	x	
long	table	1.3	x	
ship	sink	3.4	steamer	!
ask	answer	1.6	x	
wool	knit	1.6	x	
obstinate	friendly	1.4	x	
lake	water	4.0	blue	!
sick	well	1.8	x	
ink	black	1.2	x	
swim	can	3.8	water	!

Applied to the man with the paretic arm the association tests showed that the words in the list where the most disturbance occurred (long time, forgetfulness) were "proud," "pure," "arm," "bird," "death," "sin." The words he thought of as associations most frequently were "love," and "like," 8 times; "not," 6; "I," "marriage," 3; "arm," 3; "lake," 3. Now just put these words together as a picture of his condition. "I am (or was) proud that I am pure. I have sinned. I would prefer

death. I do not love my wife (marriage)." The words "arm," "bird," "lake" remain unexplained. Nevertheless a moral catastrophe is revealed.

This will be more evident to the lay mind from another case—that of a happily married woman subject to explosions of jealousy with outbreaks of violence and of running away from the house. These outbreaks she carefully concealed from the rest of the family. She wreaked her temper on her husband, who was a model man. In the association tests the strongest disturbances occurred with the words "happiness," "anxiety," "religion," "choose," "marry," "part," "death," "die." In her associations she uses "like" 13 times, "man," 10; "child," 7; "necessary," 7; "beautiful," 6; "I," 4.

It was possible to guess the story from these results alone, but it was easier to confront her with the record and show her conclusively that she has revealed something compromising to her happiness, that she is anxious about something, that religious questions are troubling her. The patient owned up that she was not happy with her husband, that she is anxious about the future and does not know what to do, that she is married outside of her religion and to a man whom she chose against the wishes of her parents, and that she is debating whether she shall part with him or die.

Another method of psychanalysis is that of running associations. This was introduced by Freud:

"The patient is told to let his mind wander with perfect freedom and to tell his thoughts as they arise. The method is useful in the most varied ways. It must first be made clear to the patient that his cure depends upon telling the truth; no matter how private may be the thought that arises, he must tell it frankly to the physician.

"This method I will illustrate by the case reported by a clergyman of Zurich. He noticed in a composition written by one of his pupils, a boy of eleven years, indications of strained relations among the members of the family. Knowing that he could not possibly get the facts otherwise, he applied a combination of the association experiment with running associations. For example, the word 'water' aroused the association 'corpse' after four seconds. Thereafter the boy associated 'ship,' a 'drowned person,' 'I saw how a drowned person was taken into a boat.' 'Now tell all the words that occur to you,' said the clergyman. 'Bathe, swimming, bathhouse, bottom, seaweed, shark, earth, stone, springboard, air, chain, beam, submarine boat, screw, no air, drowned.' 'What occurs to you now?' asked the clergyman. 'I saw some moving pictures with two divers that found gold. One cut the air tube of the other, took the gold, and went up.' The word 'diver' brought up the association of 'the dead diver in the moving pictures. We could see his pale face. We once got a wax mask representing a dying king with eyes turned up. Arno (his brother) put on the mask and wrapped a shroud around him. He looked like a ghost. I was frightened. The dying diver reminds me of this wax figure (meaning his brother in the mask).' Over and over again the boy produces series of associations ending up in some representations of his brother as dead, as in prison, as tortured, as murdered by himself, as crucified, etc. It was very evident that he hated his brother from the bottom of his soul. This he did not realize in the least himself. The information and the treatment came through this method of psychanalysis.

"The method of running association is based on certain laws of the association of ideas. One of these we may state as follows: The oftener an idea or an element of an idea has been in mind the more frequently it will appear in associations. The brother Arno was constantly in little Max's mind; no matter what he started to think about, the thought of Arno would sooner or later appear. Another law is that the intenser an idea is or the more motion it arouses the more often it recurs. A person will remember the time he made a fool of himself, no matter how much he wishes to forget it. Start any one on memory associations, and he will inevitably land over and over again on the chief topics in his mind and will involuntarily deliver his secrets over to you.

"The more the running association is freed from the control the better the information concerning the person's mind. Seat yourself in quiet and let your mind wander in associations. You will notice that at each step a dozen new things crowd in together. Instinctively you pick out one and proceed. For example, with the word 'lamp' there appear at once to my mind in half-formed condition a certain gas flame,

a certain electric light, a certain proverb, etc.; one of these I have to catch because I cannot think clearly of all of them at the same time. I catch the certain electric lamp. It is in a certain room; this leads my thoughts in that direction. If I had caught the gas flame, my thoughts would have gone otherwise."

From childhood up we have been trained to control our thoughts, to proceed in an orderly fashion, to speak only in a modest way, even to think in a modest way. This control becomes automatic. When we let the thoughts wander, we automatically catch only those thoughts that fit our training. In the presence of another person we are trained to speak only in a discreet manner; even to think otherwise is not proper. Automatically we catch only the discreet thoughts and suppress the others. In the doctor's office the conversation is freer, but even here it usually requires some training before the patient can let himself think freely.

Another method is that of assigning a topic concerning which all impromptu thoughts are to be noted down. For example, the physician tells the patient to note down on the spot each thought that arises impromptu concerning himself (the physician). Thus a patient reports that in an entirely impromptu manner the thought occurred to him that the doctor was getting bald. On another occasion he said he thought the doctor was getting stout, and so on. An entire group of these observations revolved around the signs of advancing age. This was in fact the great trouble of the patient. He felt that he was getting old. This line of psychanalysis lets a flood of light in upon the dark places of the human soul and heart:

"Another patient reports that the thought had occurred to him that the doctor was extremely considerate of the feelings of his patients, that he was really rather bashful, and so on. This simply reflected the patient's condition of bashfulness and overanxiety about how people felt toward him. Still another patient thought that the doctor must make a great deal of money out of his practice, that he dressed in expensive clothes, etc. Of course, the inference was at once clear, namely, that the patient's thoughts centered around money. I have never had an experience quite like one that Dr. Jung related to me. One of his patients, a clergyman, told him that the thought had occurred that Dr. Jung was not strictly truthful, that he was not quite honorable in dealing with his patients, that he did not believe that he led a strictly moral life, etc. Before knowing the facts of the case Dr. Jung replied, 'It is you who are the liar, you have not acted honorably with your parishioners; you are doing something immoral.' The thoughts that arise impromptu like this are always reflections of the patient's own personality."

Nor has this new method of psychanalysis produced results less remarkable in the interpretation of dreams. It seems that the dream is in reality a clue to the mental and even the physical life of far greater importance than any scientist has ever suspected or been disposed to admit. For the man who tells what he has dreamed the night before is revealing, did he but know it, the inmost secret of his whole life.

**Enlarging a Baltic Seaport.**—A project for extensive engineering work for the purpose of enlarging the port of Dantzig was discussed at a recent meeting of municipal and commercial representatives of that city. The matter bore upon increasing the size of the port at Neufahrwasser, and the canal of the port would thus be enlarged considerably so as to reach a width of some 300 feet. The outlay which is needed for this work is estimated at \$500,000, to be borne two-thirds by the State, and the remainder to be divided among the naval docks, the municipality and the commercial interests of the city.

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# SCIENTIFIC AMERICAN

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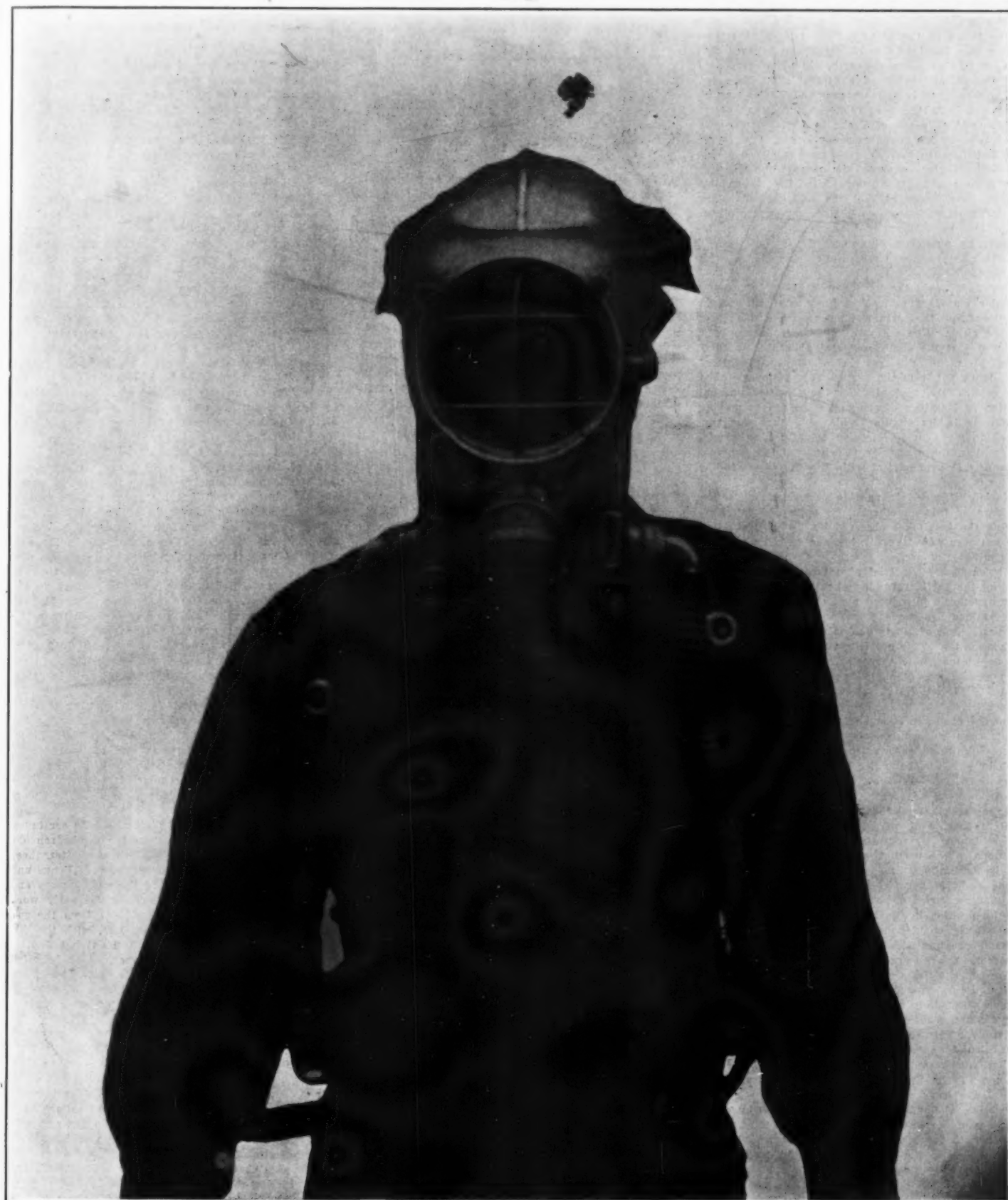
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THIS MAN IS NOT A DIVER. HE IS A MINER, WHOSE HEAD IS INCASED IN AN OXYGEN HELMET SO THAT HE MAY FIGHT HIS WAY THROUGH POISONOUS GASES AND RESCUE ASPHYXIATED COMRADES

SAVING HUMAN LIFE IN MINES.—[SEE PAGE 264.]

# The Discovery of Kepler's Laws

## An Epoch-making Astronomical Achievement

ALMOST exactly three centuries have passed since the discovery of the laws of planetary motion. In 1609 Kepler announced that the orbit of Mars is an ellipse, having the sun in one of its foci. The simple and ingenious empirical process which led Kepler inevitably to the discovery of the true form of the orbit is not generally known. This process is described by Prof. Bigourdan of the Observatory of Paris in an article in *Revue des Sciences*, which may be summarized as follows:

### I. THE FIRST LAW.

In the year 1600 Kepler went to Prague to assist Tycho Brahé in the construction of his new Rudolphine tables of the planets. The two great astronomers soon fell into discord, for Tycho believed that the sun revolved about the earth, while Kepler adopted the Copernican theory of a central sun. Moreover, Tycho was haughty and arrogant and Kepler was ill-paid and irritable. A complete rupture was averted by the sudden death of Tycho in 1601. Kepler succeeded Tycho as astronomer royal, and Tycho's accumulated treasure of observations was placed at his disposal. Kepler continued to occupy himself with the planets and particularly with the intractable planet Mars, asserting that the secret of planetary motion must be learned from Mars or remain forever unknown. In 1609, after nine years of patient research, he published his work, "De Stella Martis," in which he proclaimed the elliptical form of the orbit of Mars.

For 2,000 years the Pythagorean theory of exactly circular planetary orbits had been admitted without argument, but the earth was not placed at the center of the circle. For example, those astronomers who believed that the sun *S* revolved about the earth *T* (Fig. 1), placed the center *C* of the solar orbit at a distance *CT* from the earth. This distance, called the eccentricity, accounted for the observed unequal motion in longitude of the sun, conceived as moving uniformly in its circular orbit. A planet was supposed to move in its circular orbit, not uniformly, but with uniform angular velocity, about a *punctum aequantis* *E*, symmetrical with *T* with respect to the center *C*.

Kepler attempted in vain to represent the motion of Mars on this hypothesis. He succeeded in reproducing the longitudes observed by Tycho Brahé, but the latitudes were in error, in some cases by as much as 9 minutes of arc.

Kepler then made trial of a theory of planets, including the earth, revolving about a fixed sun. This new hypothesis introduced a new difficulty, for if the observations are made from a moving earth it is necessary, first of all, to determine the earth's motion with accuracy. This problem, very similar to that of the determination of the orbit of Mars, was attacked by a method whose simplicity attests Kepler's genius.

In Fig. 2, let *T, T', T''* represent three positions of the earth in the unknown orbit which it describes about the fixed sun *S*, and let *M* denote another fixed point, whose heliocentric coordinates are known. From these coordinates the angles *MST*, *MST'*, *MST''* can be deduced, while the angles *MTS*, *MT'S*, *MT''S* can be determined by observation. Hence, all the angles of the triangles *MST*, *MST'*, *MST''* can be determined, and, as these triangles have a common side *MS*, the relative lengths of the radii vectors *ST*, *ST'*, *ST''* can be found. By repeating this process for various positions of the earth the form of the earth's orbit can be determined.

The point *M* may be any one of the planets. If the planet's period of revolution is accurately known and its position in the heavens is observed at intervals exactly equal to multiples of this period, the planet represents a fixed point, so far as these observations are concerned.

The periodic times of the planets have been known pretty accurately since the days of Hipparchus. Kepler selected, to represent the fixed point *M*, the planet Mars, whose orbit was the ultimate object of his study. This enabled him to reverse the problem and calculate *SM*, the radius vector of Mars, after he had constructed his tables of the earth's motion.

Among Tycho Brahé's observations of Mars, which formed the basis of Kepler's work, there was little probability of finding even a few separated by exact multiples of the period of revolution, but it was only necessary that this condition should be satisfied approximately, as the observations could be reduced to the exact epochs required by the application of small corrections, which could be calculated without sensible error.

Kepler formed his tables of the earth's motion on the theory of a circular orbit and a *punctum aequantis*. From these tables he could compute the earth's radius

vector *ST* at any epoch, and could thence deduce the radius vector of Mars *SM*. He then tried to represent the observed positions of Mars by means of a circular orbit about an eccentrically placed sun. Three values of the radius vector, together with the values of the heliocentric longitude for the same epochs, supplied data for computing the three elements of the orbit of Mars: the radius, the eccentricity and the position of the line of apsides.

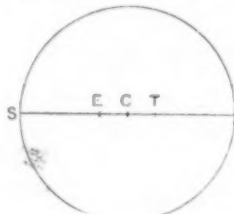


Fig. 1

These elements were already known approximately, and Kepler's results differed considerably from the known values. Furthermore, different groups of three positions gave different values of the elements. But Kepler was unwilling to abandon the old theory of a circular orbit without additional evidence.

From Tycho's observations and the old tables he determined the heliocentric longitudes of Mars at aphelion and perihelion. Then, by the empirical method indicated above, he calculated the values of the radius vector at the same epochs, i. e., the two segments of the line of apsides. Finally he assumed that the unknown orbit was symmetrically divided by that line. From these data he could calculate the radius vector at any epoch and compare it with the value obtained by the empirical method. He found

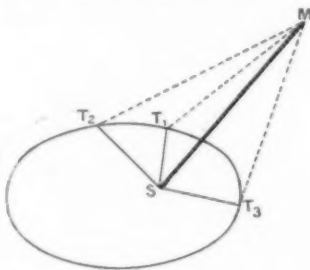


Fig. 2

that the value calculated on the theory of a circular orbit was always greater than the real or empirical value.

Kepler then definitely announced that the orbit was not circular. He at first rejected the ellipse in favor of the egg-shaped oval, but this curve likewise failed to stand the test which had eliminated the circle. At last, after long perplexity, in which he complained that his theory had gone up in smoke, and that the problem would drive him mad, he found that the despised ellipse stood the test and announced that the orbit of Mars is an ellipse having the sun in one of its foci. This is a particular case of Kepler's First

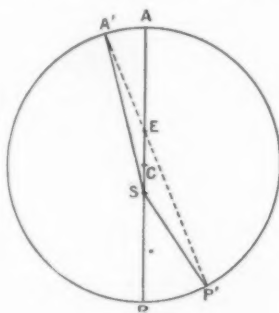


Fig. 3

Law, which he subsequently extended to all of the planets.

### II. KEPLER'S SECOND LAW.

The law of the conservation of areas, which states that the radius vector of a planet describes equal areas in equal times, evidently applies to uniform motion in a circle. Kepler saw that this law also applies, very approximately, at and near the aphelion and perihelion of a planet moving in a circular orbit,

with uniform velocity about a *punctum aequantis* *E* (Fig. 3), placed opposite the sun *S*, and equidistant with it from the center of the circle *C*. In the figure *AA'* and *PP'* represent arcs described, in equal short intervals of time, from the aphelion *A* and the perihelion *P*. *A'*, *E* and *P'* lie in the same straight line, by the hypothesis of uniform angular velocity about *E*. The areas described by the radius vector in the two equal intervals are *ASA'* and *PSP'*. Owing to the symmetrical position of *E* and *S*, with respect to *C*, *AE* = *PS*, and *AS* = *PE*. Hence

$$\frac{ASA'}{PSP'} = \frac{\frac{1}{2}AS \times AA'}{\frac{1}{2}PS \times PP'} = \frac{AS}{PS} \times \frac{AE}{PE} = \frac{AS}{PS} \times \frac{PS}{AS} = 1.$$

Having established this much, Kepler felt a moral certainty that the law of areas applied also to the ellipse, but he could not find a satisfactory demonstration of this fact until some years later.

Kepler's dedication of "De Stella Martis" to the Emperor Rudolph II., containing a poetical appeal for means to extend his researches to the other planets, is worth quoting in the following condensed form, as an illustration of the writer's imagery and the spirit of the times:

"I bring Your Majesty a noble prisoner, the fruit of a laborious and difficult war. It is not the first time he has been a captive, for long ago the terrible god of war was caught in Vulcan's net. Hitherto he has triumphed over all human devices. In vain have the astronomers employed every resource and put all their troops into the field. Mars, mocking their efforts, has shattered their engines and their hopes, retrenched himself in his impenetrable domain and concealed his movements from their spies. The valiant Captain Tycho Brahé has studied the enemy's mysterious movements almost nightly during twenty years, and has bequeathed his observations to me. In the course of the war our camp has been desolated by death, pestilence and sedition. Many soldiers deserted and were replaced by raw recruits, and even the rations ran short.

"At last the enemy sent his capitulation by the hand of his mother, Nature. He gave his parole and Arithmetic and Geometry escorted him to our camp. He has since proved that his parole can be trusted and he asks but one favor from Your Majesty. His father Jupiter, his grandfather Saturn, his brother Mercury and his sister Venus are still in the sky. He pines for their society and longs to see them also enjoying your hospitality. For this purpose the war must be prosecuted with vigor; but money is the sinews of war, wherefore I beseech Your Majesty for the funds required for the levy of fresh troops."

### III. KEPLER'S THIRD LAW.

The Third Law was not discovered until 1618, after twenty-two years of research and speculation. In the "Mysterium Cosmographicum," published in 1596, Kepler writes:

"I propose to show that God, in creating the universe and arranging the spheres, had in view the five regular solids of geometry, and fixed by their dimensions the number, proportions and motions of the spheres. Take the sphere of the earth as a unit and circumscribe it with a regular dodecahedron. The sphere that contains this dodecahedron is the sphere of Mars."

The spheres of Mars and Jupiter, Kepler continues, are similarly related to a regular tetrahedron described about the former and within the latter, those of Jupiter and Saturn to a cube, those of Venus and the earth to an icosahedron and those of Mercury and Venus to an octahedron. Kepler in this early work compares the distances of the planets from the sun derived from this geometrical system, with the distances given by Copernicus, and finds that Jupiter alone presents a serious discrepancy, which he attributes to the inaccuracy of the value given by Copernicus. Kepler was satisfied with the result, although he could not then find a simple law connecting the distances of the planets.

He returns to the subject in the "Harmonices Mundi," a work in five volumes, published in 1619, in which he discusses polygons, the five regular solids, astrology, politics, the faculties of the mind and other things. He revives the Pythagorean analogy between music and the harmony of spheres, and calls Saturn and Jupiter the bass voices, Mars the tenor, Venus the contralto and Mercury the soprano or falsetto of the celestial choir.

From this chaos of dreams emerges Kepler's Third Law, which is thus formulated:

"The proportion between the periodic times of two planets is exactly equal to the sesquialternate ratio of their mean distances from the sun." The sesquialternate ratio is the ratio of the 3-2 powers. In

other words, the squares of the periodic times are proportional to the cubes of the mean distances, as the Third Law is usually expressed. Contrary to his wont, Kepler does not give the history of this discovery, but the work terminates with the following famous passage:

"Eight months ago I saw the first ray of light; three months ago I saw the dawn; three days ago

I saw the sun in his splendor. I give myself up to enthusiasm. I voluntarily defy mankind with the ingenious confession that I have stolen the golden vase of the Egyptians to make of it a tabernacle to my God, far from the bounds of Egypt. If you pardon me I shall rejoice, if you reproach me I shall endure it. The die is cast. I have written my book. It will be read by the present generation or by posterity,

it matters not. It can await its reader. Has not God waited six thousand years for a contemplator of his works?" He concludes with a prayer of thanksgiving to the Creator.

Thus were established Kepler's three laws of planetary motion, which led Newton to the conception of universal gravitation, the basis of modern astronomy.

## Preparation of Pure Radium Salts\*

### The Process of Fractionation Employed

By Madame Curie

To EFFECT the separation of pure radium chloride from the barium chloride with which it is associated, I have subjected the mixed chlorides to a fractional crystallization first from pure water, and then from water acidulated with hydrochloric acid. This process is based upon the fact that radium chloride is less soluble than barium chloride.

A saturated solution of the chlorides in pure distilled water at boiling temperature is prepared, and is left to crystallize in a covered vessel. After cooling, a deposit of fine crystals is found upon the bottom of the crystallizing vessel, and the supernatant solution can be readily poured off. If a sample of the mother liquor is evaporated to dryness, and the residues tested, it is found to be five times less active than the portion originally crystallized out. In this way, the chlorides are separated into two portions, A and B, or which A is much more active than B. The operation is now repeated with each of these parts, thus again obtaining from each a further crop of two parts. The less active portion obtained from A is then united with the more active portion obtained from B, these two portions having approximately the same activity. The result of this step is three fractions, which are once more subjected to the operation described. The number of fractions thus prepared is not allowed to increase indefinitely, for, as the process goes on, the activity of the soluble portion becomes less and less. When it has sunk to an insignificant value, the particular portion is eliminated from the process. After a suitable number of fractionations, the most difficultly soluble portion, which is richest in radium, is also withdrawn from the operation.

A fixed number of fractions is maintained. After a series of crystallization the saturated solution of one fraction is united with the crystals of the next following fraction. When, however, the most readily soluble fraction is discarded at the end of a series, a new readily soluble fraction is prepared in the next series, and the most active crop of crystals is taken out of the process. By systematically following out this scheme, a very regular mechanism of fractionation is obtained, the number of fractions, and the activity of each fraction, remaining constant, each being about five times as active as the next lower in order. At the one end an almost inactive product is discarded and at the other end a chloride enriched in radium is collected. The total quantity of material diminishes continually, and the several fractions become smaller and smaller as their activity increases. The work is begun with six fractions, and the activity of the chloride discarded at the end is only one-tenth that of uranium.

The accompanying diagram represents the scheme of such a fractionation. Each point represents a crop of crystals from the portion indicated by the affixed numeral. The two arrows extending from a given point indicate the two products, crystals and mother liquor, resulting from each crystallization, e. g., to the left, crystal, to the right, mother liquor. Where two arrows converge to a point, this indicates the union of the crystals separating from one portion with the solution from the immediately preceding portion. The outwardly directed arrows signify that the final product has been removed from the fractionating process.

When a large proportion of the inactive substance has been in this way eliminated, and the quantity of material has consequently been much reduced, it is no longer worth while to separate out these portions at such low activity. The last members in the series are then discarded, and are replaced from above by previously collected active chloride, with the effect that a chloride richer in radium is precipitated than at first. This is continued until the crystal crops at the beginning of the series represent pure radium chloride. If the fractionation has been carried out perfectly, the amount of intermediate products left over will be very small.

When, in the course of the fractionation, the bulk of the individual fractions has been much reduced,

the separation by crystallization becomes less effective, because the solutions cool off too rapidly, and the volume of the mother liquor decanted off becomes too small. At this stage it is advantageous to add a definite amount of hydrochloric acid to the water used for dissolving, gradually increasing the amount of acid so added, as the fractionation proceeds. This addition has the advantage that the volume of the solution is thereby increased, owing to the fact that the chlorides are less soluble in dilute hydrochloric acid than in pure water. At the same time, the fractionation becomes more thorough, the difference between the fractions separated from a given stock is increased. If the acid is added in considerable concentration a very excellent separation is obtained, and the fractionations may be reduced to three or four. It is therefore a great advantage to begin with the addition of hydrochloric acid just as soon as the diminished amount of material permits this step to be taken without inconvenience.

The crystals which separate out from strongly acid solutions are long and needle-shaped, and identical in appearance, whether they be barium chloride or radium chloride. Both these are doubly refractive. The crystals of the barium chloride containing radium are colorless; if, however, the radium content reaches a certain limit, the crystals assume, after standing for several hours, a yellow color, ranging toward orange, or sometimes a fine rose tint. This color dis-

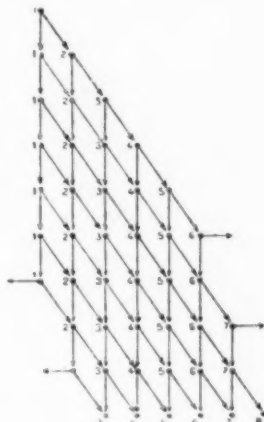


DIAGRAM INDICATING THE SCHEME OF SUCCESSIVE FRACTIONAL PRECIPITATIONS

appears on dissolution. The crystals of pure radium chloride do not become colored in this way, or at least not as rapidly, so that the coloration appears to be dependent upon the simultaneous presence of radium and barium. The maximum coloration occurs when the amount of radium assumes a certain definite proportion, and this furnishes a means of gauging the progress of the fractionation. So long as the most active fraction becomes colored, we know that it still contains a considerable amount of barium; if it no longer becomes colored on standing, while the fractions of lower order do, then the colorless portion is approximately pure radium chloride.

I have sometimes observed crops of crystals which consisted partly of colorless crystals, and partly of others, which became colored upon standing. Perhaps they might have been separated by picking them out individually, but this was not attempted.

Toward the end of the fractionation the successive fractions no longer display the same relative activity, nor is the proportion of their activity as regular as at the beginning of the process; this, however, does not cause any serious disturbance in the progress of the fractionation.

In working up a few kilograms of the chlorides obtained from a ton or more of the residues used as raw materials, it is necessary to modify somewhat the mode of procedure. The first fractionation is in this case carried out at the factory, so that after eliminat-

ing ninety per cent of the barium salt, a product enriched in radium can be delivered from the factory. This first fractionation requires comparatively large volumes of the saturated solutions and is carried out in cast-iron kettles. In place of distilled water rain water or river water as poor in dissolved salts as possible, is used, from which all sulphates have been carefully precipitated by the addition of a small excess of barium chloride.

The separation of radium can also be carried out by the fractional precipitation with alcohol of an aqueous solution of the barium chloride containing radium. I used this method at first, but subsequently abandoned it in favor of the one described above, which assures greater uniformity. At times, however, I have made use of the precipitation by alcohol, to purify radium chloride containing a small amount of barium chloride admixed with it. The latter remains dissolved in the slightly diluted alcohol, and can be thus removed.

Giesel, who has been occupied with the preparation of radioactive bodies since the publication of our first investigations, recommends for the separation of barium and radium the fractional crystallization of the mixed bromides from an aqueous solution. I have found that this method is very advantageous, especially at the beginning of the fractionation. This, however, is the case only if the amount of salts to be fractionated is not too large. If there are several kilograms to be treated, the use of a corresponding amount of hydro-bromic acid becomes objectionable, partly on account of its high price, and also because the cast-iron kettles are more easily attacked by the bromides than by the chlorides. Nevertheless, it is advantageous to convert into bromides the chlorides obtained from the first fractionation as carried out in the factory, which are greatly reduced in bulk as compared with the original raw material. In this way, a more rapid fractionation is secured, so long as the quantity of material is not too greatly reduced. When, however, the amount of the salt is quite small, working with the bromides is less satisfactory than with the chlorides, owing to the fact that the former are on the one hand much more soluble, and on the other hand much more subject to change than the latter. A solution of the bromide very rich in radium, in water or dilute hydro-bromic acid, undergoes very rapid alteration with liberation of bromide. For this reason it is, in my opinion, advantageous to convert salts of high radium content into chlorides in preparing a pure and stable radium salt. In the dry state, the chloride is more sharply defined and more stable than the bromide, and does not undergo any appreciable spontaneous change.

Whatever process of fractionation is employed, it is always useful to control the course of the process by measuring the activity of the product.

It should be emphasized that a radium compound which has been prepared in the solid form, either by crystallizing or precipitating from a solution, does not have a constant activity from the start. The activity increases for about one month to a limiting value which thereafter remains constant. The final activity is five or six times as great as the initial activity. These changes must be taken into account in measuring activity. The final activity is more clearly defined, but in the course of chemical operations upon radium salts, it is more practical to measure the initial activity of the solid product.

While the salt submitted to fractionation has, of course, always undergone a previous purification, it is nevertheless often desirable to purify once more a salt of high radium content. The fractionation itself of course effects a certain purification, inasmuch as traces of the salts which are very readily soluble in acidulated water (e. g., those of calcium, iron and magnesium, etc.) are eliminated. On the other hand, however, traces of lead chloride or bromide accumulate with the radium salt in the difficultly soluble portions. For this reason, it is, generally speaking, necessary to treat the salts of very high radium content with hydrogen sulphide before proceeding to the final elimination of the barium.

\* Extract from a work entitled "Traité de Radioactivité." Translated for the SCIENTIFIC AMERICAN.

# International Standard Time

## Its History and Its Recent Adoption in France

THE French Senate recently passed a law, which was passed by the Chamber of Deputies fourteen years ago, and which will make the legal standard time in France 9 minutes and 21 seconds slower than Paris mean solar time, which is the present French standard. The reason for selecting this interval of 9 minutes and 21 seconds, the reservations by which a complete and formal adoption of the meridian of Greenwich has been evaded, and the advantages and disadvantages of the change, are discussed in *La Revue des Sciences* by Prof. Bigourdan, of the Observatory of Paris. Prof. Bigourdan's article, an abstract of which is here presented, also contains an outline of the history of international standard time.

Every place on the earth's surface has its own local time, and the difference between the local times of any two places is proportional to the difference of their longitudes, one hour corresponding to 15 degrees, or 4 minutes to 1 degree of longitude. When the stage-coach was the most rapid means of travel, the difference in local time caused no great inconvenience, but the development of the railway soon made it necessary to adopt a single standard of time for all the stations of a line, or even of a country. The local time of Paris was naturally selected as the standard of railway time throughout France, but the local times of other places long continued in use for local purposes. The difference between local and railway time varied according to the distance east or west

however, that the advocates of a universal time standard limited its employment to railways, steamship lines, mails, telegraph systems and similar uses.

The question of a universal time standard is necessarily connected with that of an international prime meridian, and the two questions were discussed together at the geographical congress which met in Venice in 1881, at the meeting of the International Geodetic Association in Rome in 1883, and elsewhere.

Geographers have always felt the necessity of reckoning all longitudes from a single meridian, but the location of this prime meridian is arbitrary and has varied greatly. In the 17th century Richelleu selected the meridian of Ferro, the most westerly of the Canary Islands, and the most westerly land known to the ancients. The meridian of Ferro was for a long time accepted almost universally as the prime meridian, but as its longitude was not accurately known it was arbitrarily assumed, at the suggestion of the celebrated geographer Delisle, to be 20 degrees west of Paris. This assumption made the meridian of Paris the real prime meridian, and in course of time each of the great nations adopted the meridian of its principal astronomical observatory as a prime meridian.

When the return to a single prime meridian was discussed at the congresses of Venice and Rome it was agreed that this meridian must pass through an observatory of the first class, situated in a region free

the dotted line, marked 0 degrees. The hour section marked 0 at the bottom of the map is bounded by two meridians drawn  $7\frac{1}{2}$  degrees east and west of the prime meridian. The hour section marked 1 extends  $7\frac{1}{2}$  degrees east and west of its central meridian (not drawn), which is 15 degrees east of Greenwich, and so on. Each country which has adopted the system uses as its time standard the time of the hour section to which its territory most nearly corresponds, or, if it extends over several hour sections, employs several standards, determined by the same rule, for its various political divisions.

This system possesses most of the merits and none of the defects of a single universal time standard, for local time never differs from standard time by much more than half an hour, and the standard times of any two places or countries differ by a whole number of hours, the minutes and seconds being everywhere the same. The figures at the bottom of the map mark the hour of each section when it is midnight at Greenwich. (The numbers of the left-hand half indicate afternoon hours and must be diminished by 12 to agree with the clocks used in most countries.) Special names have been given to the most important hour sections, as follows:

Name.	Section.	Time.
West European .....	0	12 P. M.
Mid-European .....	1	1 A. M.
East European .....	2	2 A. M.
Pacific .....	16	4 P. M.
Mountain .....	17	5 P. M.
Central .....	18	6 P. M.
Eastern .....	19	7 P. M.
Intercolonial .....	20	8 P. M.

France is included almost entirely in the section of West European or Greenwich time, which is 9 minutes and 21 seconds slower than Paris time.

The difference between the longitudes of two places can be obtained either by linear measurement and triangulation or by determining the difference between their local mean times by astronomical observations. The difference in longitude of the observatories of Paris and Greenwich has been repeatedly determined by each of these methods, which often give discordant results. In the present case, in which the difference in time is the real object of search, the results obtained by the second method are naturally adopted. Accurate determinations of this kind have been possible only since the introduction of the electric telegraph. The results obtained by various observers since 1854 are given below:

	Min.	Sec.
1854 Donkin and Faye .....	9	20.51
1872 Coast Survey .....	9	20.97
1888 Lewis and Turner .....	9	20.85
1892 Hollis and Turner .....	9	20.79
1902 Dyson and Hollis .....	9	20.93
1902 Bigourdan and Lancelin .....	9	20.99

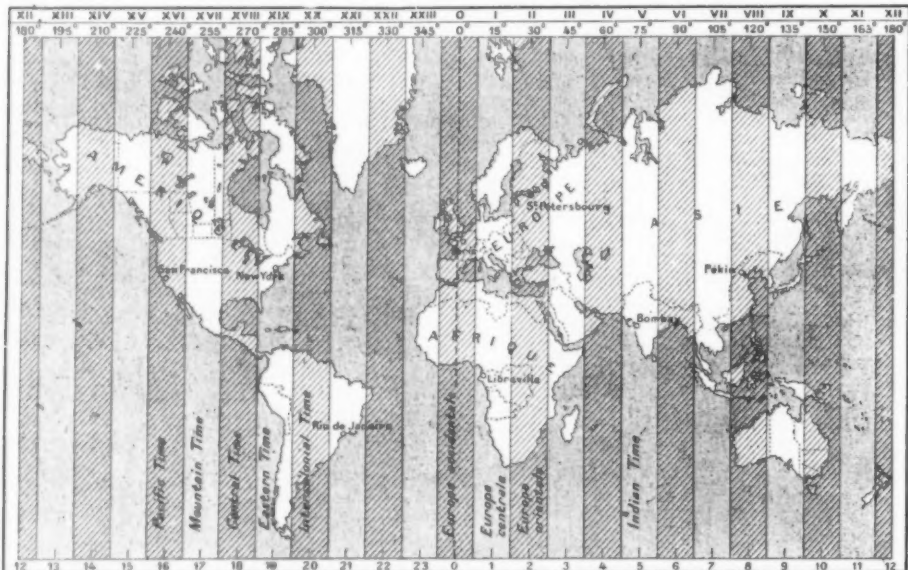
The value 9 minutes, 21 seconds, is sufficiently accurate for practical purposes.

The law recently created contains only one article, which reads: "The legal time in France and Algeria is nine minutes and twenty-one seconds slower than Paris mean time." In this form the law was passed by the Chamber of Deputies in 1897, and by the Senate in 1911. In the original form of the bill, introduced in the Chamber of Deputies in 1896, the meridian of Greenwich was explicitly adopted. The change was made in order to prevent sinister interpretations, which might have killed the bill.

The question of the meridian is left untouched by the new law, which applies only to railways, mails and civil affairs in general. The meridian of Paris remains the standard for the navy, merchant marine, astronomers and geographers, and more than 3,000 official maps and 600 volumes of nautical instructions remain unchanged.

The change brings unquestionable advantages in connecting French with foreign railway and telegraph schedules and meteorological bulletins, and terminates the complete isolation of France in respect to time standards. On the other hand, it presents the slight disadvantage of substituting for the meridian of Paris, which divides the country almost equally, a meridian lying much farther westward. But the difference between local and standard time will not be much greater at Nice than it was formerly at Brest.

The national amour propre has been wounded severely, especially as the meridian of Paris was the only one that could pretend to challenge the supremacy of Greenwich, but the French may console themselves with the thought that the new time is not English but international, and, furthermore, that it is ingeniously defined by the law as "nine minutes and twenty-one seconds slower than Paris mean time."



MAP OF THE WORLD, DIVIDED INTO HOUR SECTIONS

of Paris. Local time was 20 minutes faster than railway time at Nice, on the eastern frontier, and 27 minutes slower than railway time at Brest, on the western frontier. The local time gradually lost importance and the railway or Paris time gained, until in 1891 the passage of the law which made Paris time the legal standard for all France and Algeria was scarcely noticed by the public. The same practical conditions led to the enactment of similar laws in other countries, each of which, as a rule, adopted the local time of its principal astronomical observatory.

This simplification, however, produced remarkable diversities of time standards in some regions. The Lake of Constance, for example, is bounded by five countries—Switzerland, Baden, Wurtemberg, Bavaria and Austria—each of which had its separate national time standard. The confusion thus created in railway and steamboat time-tables and in the minds of travelers may be imagined. In going from Paris to Constantinople, a traveler was compelled to set his watch ten times.

These inconveniences suggested the adoption of a single time standard for all countries, but the impracticability of this idea is evident from the obvious fact that a single standard is inadequate for one country of great extent in longitude. The United States, for example, covers five hours in longitude, and the winter sun is rising on the Pacific coast when it is noon on the Atlantic coast. The adoption of a single standard for the whole world would produce an intolerable displacement of traditional hours in most places, and, though the Japanese are ardent lovers of science and progress, it is not to be supposed that they would consent to have the sun set at 9 o'clock in the morning. It should be added,

from volcanic and other disturbances. The choice was practically limited to the meridians of Greenwich and Paris.

The latter had played a most important part in the 18th century, in connection with the numerous expeditions sent out by the Paris Academy of Sciences for the determination of longitudes in Denmark, Cayenne, Senegambia, the West Indies, Siam, China, Cape Colony, etc., which resulted in the correction of errors amounting in some instances to 27 degrees. In the expedition to Cayenne, Richer made the memorable discovery of the shortening of the seconds' pendulum in approaching the equator. The exact measurements instituted by Picard and based on the meridian of Paris were extended from France to the Arctic circle, the equator and the Cape of Good Hope. In short, geodesy continued for a century to be an exclusively French science.

Subsequently, the meridian of Greenwich gained importance, chiefly in the determination of longitudes by the moon, and nine-tenths of the mariners of the world use English charts in which longitudes are reckoned from Greenwich. The Rome congress of 1883 consequently decided in favor of Greenwich, and this choice was confirmed by the international conference held in Washington a year later.

The Canadian Institute had already proposed to divide the earth's surface into 24 sections, each embracing 15 degrees of longitude, and to employ in each section a time standard differing by one hour from those of the adjacent sections. This system was adopted in 1883 by the American railways, and has since been adopted for general use in America and Europe. It is illustrated by the accompanying map. The prime meridian of Greenwich is represented by

# The Air-brake as Related to Progress in Locomotion—IV\*

## The History of a Great Invention

By Walter V. Turner, Chief Engineer, Westinghouse Air Brake Co., Pittsburg, Pa.

Concluded from Supplement No. 1842, page 246

### STARTING AND STOPPING.

The problems of deceleration, retardation and the flexible control of trains must receive more and more attention from a scientific and technical standpoint, in order that to-day theory and practice may be combined to produce the best results in the shortest time. This is necessary if the brake is to efficiently and satisfactorily meet the wonderfully changed conditions which have developed since the invention of the quick action, automatic brake. The high speeds and great weights of the present day requiring that advantage be taken of every opportunity offered to increase and flexibly control braking power.

Starting and stopping of trains are complementary factors in the problem of making time between stations, therefore it is evident that the best results can only be obtained where both factors are given due consideration. Generally, the starting factor is the only one fully considered, or, at least, the one more fully provided for, and this notwithstanding that better results can be obtained if both are considered and the more efficient brake system installed.

In another sense, the question of stopping is the most important, as the safety of the service and the freedom of delays to a great degree depend upon it. The measure of the value of the brake is two-fold—(1) the ability to stop in the shortest possible distance when necessary, and (2) to permit short, smooth and accurate stops being made in regular operation. Therefore both these factors should be considered when design is under way.

Unfortunately, the brake is usually looked upon as a safety device only, and it is because of the prevalence of this idea that its installation and maintenance do not receive the consideration merited. Considering the investment, there is no part of the railway equipment that will give greater material returns than the brake when properly installed, operated and maintained. If the brake could to some extent be separated from the idea or impression that it is a safety device only and proof advanced to show that it makes possible the hauling of heavier cars—in fact, makes the heavy car possible—that it makes possible, faster and more frequent service—as much or more than does the locomotive, the block signal and the good roadbed—and that, if given the consideration it should have, it would increase the possibilities, profits and value of all these things—its importance would be more fully appreciated and, therefore, at least the same consideration be given to its design and installation that is accorded to other parts of railway equipment. A safety device, the brake is, *par excellence*; but it has other reasons for its existence.

Very few, perhaps, realize that the brake under a single car is much more powerful than the locomotive that pulls the train, yet this will be apparent to any who examines the records of a dynamometer car

stop the train. The comparison is somewhat startling, but it is only because the condition is one of those commonplaces which have been taken for granted so long that they are accepted as inherent rather than being given the degree of consideration which their significance warrants. Fig. 22 is an illustration of the facts stated, taken from the records of a run dur-

celerate a train to a speed of sixty miles an hour in certainly not more than a minute and a half, and probably not more than one minute's time. That means that the brake is going to be even more important in the future than it has been in the past. In proportion as we accelerate, we must perforce be prepared to decelerate. The ability to accelerate, or even

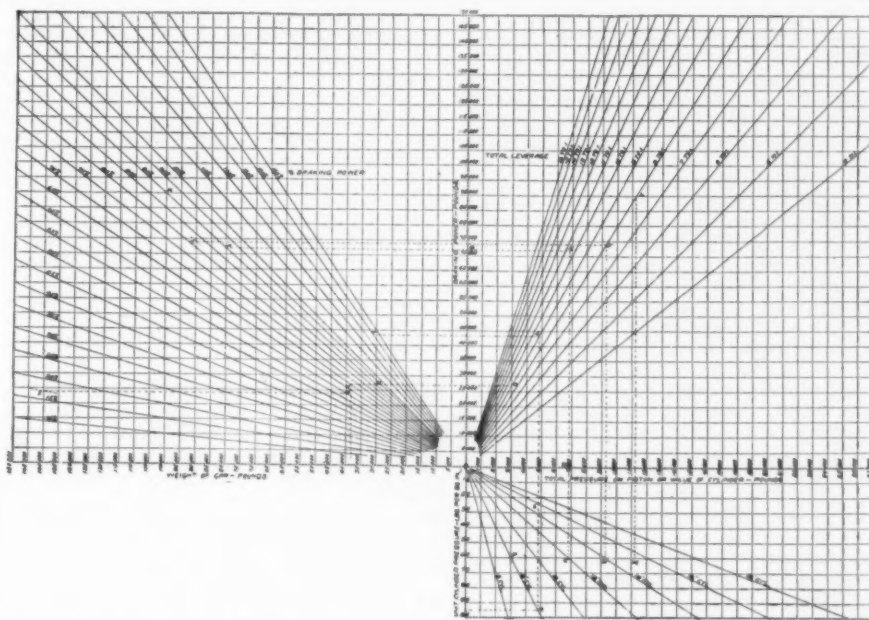


FIG. 23.—CHART SHOWING RELATION BETWEEN SIZE OF BRAKE CYLINDER, BRAKE-CYLINDER PRESSURE, TOTAL LEVERAGE RATIO, BRAKING POWER, AND WEIGHT OF CAR

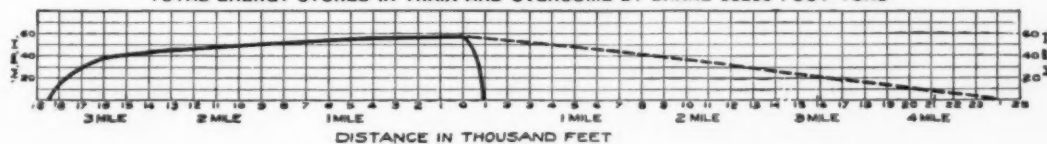
ing a series of tests at Absecon, N. J., 1907, the train being composed of a locomotive and ten cars. What it took the locomotive nearly six minutes and a distance of about three and a half miles to accomplish was overcome by the brakes in less than twenty seconds and within a distance of about one thousand feet. The broken line represents what the stop might have been if no brakes had been used, i. e., the train brought to rest by the resistance of the air, and journal friction. All the elements so strongly contrasted in Fig. 22 are familiar in themselves, but their reciprocal relationship is often overlooked. The average passenger train of to-day can be stopped from a speed of sixty miles per hour in about twenty seconds' time. To build a steam locomotive that would accelerate a train in the time and distance

to run at high speeds, must be measured by the ability to stop.

As an example, however, of how little this is appreciated such a question as the following is often asked and a categorical answer apparently expected: "In what distance should a train be stopped from a speed of fifty miles per hour?" Perfectly simple, isn't it? Here we have one known factor, from which we are expected, apparently, to derive all the other factors which are of equal importance and must be known before an answer of any value can be given to such a question. A few of these factors are: The light weights and loads of the vehicles composing the train; the percentage of braking power used with engine and cars; whether or not all wheels, including truck and trailer (if any) of the locomotive were

CLASS E-2-D LOCOMOTIVE.  
TOTAL WEIGHT OF TRAIN 559.6 TONS.  
ACCELERATION DISTANCE OF 18500 FEET  
TIME OF ACCELERATION 5 MIN. 47 SEC.  
DECELERATION DISTANCE OF 954 FEET.  
TIME OF DECELERATION 18.7 SEC.

TOTAL ENERGY STORED IN TRAIN AND OVERCOME BY BRAKE 63250 FOOT TONS



BROKEN LINE REPRESENTS STOP WITHOUT THE USE OF BRAKES.

NOTE.—THE CALCULATED STOP WITHOUT BRAKES WAS OBTAINED BY ASSUMING 8.6 POUNDS PER TON RETARDATION DUE TO WIND RESISTANCE AND JOURNAL FRICTION. TRACK LEVEL.

FIG. 22.—ACCELERATION AND DECELERATION CURVES; ABSECON, N. J., TESTS

alone attached to an engine, the stops being made by brakes on the dynamometer car. Few realize that it takes a locomotive perhaps five minutes, perhaps ten minutes, and a distance of some miles—six or seven—to attain a speed of sixty miles per hour. Imagine the condition of affairs which would exist if it took a brake that length of time and distance to

that the brake stops it, would be impossible, for in order to have the necessary adhesion to the rails, which permit of developing the required drawbar pull, the steam locomotive would have to weigh approximately twice as much as the train itself, which is, of course, prohibitive. Electric locomotives, however, are no longer to be regarded with uncertainty or as mere experiments, and there is every reason to believe that the electric locomotive will be able to ac-

celerated; what type of brake equipment was used; what pressures were carried; whether the train was accelerating or decelerating; on a curved or straight track; on an ascending or descending grade, or level; the condition of the rail; whether the brakes were applied in service or emergency, or ordinary service and then emergency; the piston travel on each vehicle; the losses to friction of parts, brake-beam release springs, etc.; wind resistance; quality and thickness

\* Presented at the meeting of the Mechanical and Engineering Section.

of brake shoes and method of hanging them, for this affects materially the efficiency of the brake, both as to absorbing power and lengthening the piston travel which reduces the pressure otherwise obtainable. Furthermore, it should by no means be understood that the precise effect of each of these could be accurately calculated, even though full information were at hand, and a little thought will make it evident that each of the factors mentioned above may have a considerable influence on the length of the stop.

These things are merely mentioned to emphasize the great importance of the air-brake and the necessity for considering carefully what principles govern its action. It does not make very much noise. It does not occupy so prominent a place in the papers as electricity, for instance; yet it has been much more of a factor in railroad development up to the present time than electricity.

Now form a comparison between the propelling and stopping mechanism of our steam railroads. The locomotive is much in evidence, being large and of powerful appearance and placed in the most conspicuous place in the train. The brake is, outwardly, a comparatively insignificant piece of apparatus, installed on the different vehicles of the train; placed underneath the cars where it is hard to find, and seldom observed by the traveler. The very fact that it is so distributed over the train is one reason for its power and efficiency. When we realize the forces handled by the two devices, and the great difference in point of time in which their work is accomplished, our respect for the brake will be stimulated, since it must be capable of dissipating the energy, stored by the locomotive in the train, in but a fraction of the time required by the locomotive to do this, if the safety of transportation is to be preserved.

#### FUNDAMENTAL PRINCIPLES IN BRAKE DESIGN.

In the establishment of a logical basis of brake design, applicable to the conditions under which brakes in general must operate and involving a determination of the essential elements of an elementary brake system for any given car, the starting point must be the light weight of the car. Fortunately this can usually be determined in advance to any desired degree of accuracy. For convenience, suppose the car to be fully equipped with a complete brake equipment and by an analysis of the factors involved in stopping the car, determine how these factors may best be provided for in the design.

Assuming that the wheels do not skid, the actual braking force acting on a car when the brakes are applied is the force of the friction between the brake shoes and the wheels, tending to retard the rotation of the wheels and thus stop the car. The relation which this bears to the energy stored up in the moving car, provided the "adhesion" of the wheel to the rail is not exceeded, determines the effectiveness of the brake and the length and time of stop. The energy of the moving car consists of two parts—that of the car as a whole due to the velocity of translation, and that of the revolving wheels, due to their rotation, and varies as the weight of the car and as the square of its velocity.

The latter may roughly be taken as 5 per cent of the energy of translation for 12-wheel cars and as 2 per cent of the energy of translation for 8-wheel cars. In ordinary calculations, however, this factor is usually neglected, and properly so, because for modern rolling stock the resistances other than as derived from the brakes, such as internal friction, air resistances, flange friction and so on, has been shown by actual experiment to at least equal if not to exceed the inertia effect of the revolving parts. Consequently a greater error is made by considering the energy of rotation without at the same time taking into account the resistances to motion which exist due to other causes than the brake shoes (which, it should be noted, are usually indeterminate and subject to considerable variation) than to assume that these two opposing factors neutralize each other.

The frictional force between the brake shoes and wheels depends on the pressure acting on the shoes and the coefficient of friction between the shoes and the wheels. In making a stop, therefore (it being assumed throughout that the wheels do not skid), the factors involved, so far as retarding the rotation of the wheels is concerned, are:

1. The total amount of brake-shoe pressure in pounds, commonly called the "braking power."
2. Coefficient of friction between the shoes and the wheels, by which the brake-shoe pressure must be multiplied in order to determine the actual retarding force.
3. The weight resting on the wheels.
4. The velocity of the car.
5. The rotative energy of the wheels.

Only one of these factors can be controlled even partially in service or fixed arbitrarily in designing the brake system, viz., the pressure on the brake shoes. Inasmuch as the wheels must not skid when the weight resting on the wheels is least—that is, when the car is not loaded—the light weight of the

car must be taken as the basis of calculation regarding brake-shoe pressure, except in the case of some form of "empty and load" brake. Since the "braking power" is, by custom, measured by a scale of percentages wherein 100 per cent represents a shoe pressure on each wheel equal to that wheel's pressure on the rail, the problem is then to determine and insure the obtaining of the proper relation between the brake-shoe pressure and the light weight of the car.

As pointed out above, the factors involved, such as frictional coefficient, speed, weights, etc., are so subject to variation in service that no theoretical conditions can determine the proper nominal percentage braking power (i. e., the ratio of brake-shoe pressure to light weight of car) which shall best meet average road conditions. This can be fixed only by experiment and experience, and is subject to modifications as conditions change or become more thoroughly understood. For example, many years' experience has proven that 90 per cent braking power for passenger cars gives satisfactory braking effects with a reasonable margin against wheel sliding and sufficient power for service stops. This was determined by the results obtained on the lightest cars. So far as wheel sliding is concerned, a 150,000-pound car braked at 95½ per cent has practically the same margin against wheel sliding as a 70,000-pound car braked at 90 per cent. But if the percentage of braking power is varied, the uniformity of service braking effect, other factors being the same, is lost. Therefore, the percentage of braking power determined as a satisfactory maximum for the lightest cars must be adhered to on all cars, in order to bring about as nearly as possible the uniform results which are necessary for satisfactory service operation.

Having, therefore, chosen a certain percentage of braking power which should be obtained on all cars, it is evident that what actually is obtained, in any given instance, depends on the total leverage ratio and the pressure per square inch on the brake piston. It will be apparent that all resistances between the brake piston and brake shoes, such as release springs, reactions of hanger links, friction of rigging, etc., must necessarily be ignored until the essential factors in the design are determined upon.

The total leverage ratio is fixed within certain limits by purely mechanical consideration, with regard to piston travel, shoe clearances, etc., and once the foundation brake rigging is designed, remains always the same.

Hence in any given case the percentage of braking power actually obtained depends entirely on the pressure existing in the brake cylinder, which varies in practice from zero to the maximum obtained when an emergency application is made.

In designing the brake system for a car, therefore, the leverage ratio and size of brake cylinder must be so proportioned as to give the required braking power in pounds, with some arbitrarily chosen pressure in the brake cylinder. Evidently this braking power will be obtained in practice when the brake-cylinder pressure is that on which the design of the brake system was based. For any pressure lower or higher than this, the braking power, in pounds, will be correspondingly lower or higher than the nominal. Furthermore, the actual percentage of braking power (ratio of brake-shoe pressure to weight on wheels) varies not only with the brake-cylinder pressure, but also with the condition of the car—whether loaded or empty.

From a consideration of these conditions it seems evident that it is practically impossible to provide for even an approximate uniformity of brake action on different cars in service by any method of design. The best that can be done is to establish and adhere strictly to the assumed standards upon which such designs are based.

1. The "percentage of braking power" in terms of the light weight of the car.

2. The brake-cylinder pressure upon which this percentage is based.

The former, as has already been stated, must be determined from experiment and experience. The latter must be chosen arbitrarily, but it should have the same value for all brake calculations, in order to insure a common base being universally used and understood. Fig. 23 graphically illustrates the relations existing between these two factors for different weights of cars and total leverage ratios. The question now is, therefore, "What brake-cylinder pressure should be used as a basis in designing the brake systems of all types and classes of cars?"

With a given auxiliary reservoir charged to a standard pressure, and with a given brake cylinder having standard piston travel, a certain definite pressure of equalization is obtained, which is constant so long as the other factors involved are kept constant.

When an emergency application is made, since a portion of the air in the brake pipe or other source of supply is used in addition to that in the auxiliary reservoir, the resulting brake-cylinder pressure is

augmented in proportion, and a higher maximum pressure therefore obtained. Evidently its value must depend upon the relation which the supplementary brake-pipe volume bears to that of the auxiliary reservoir and brake cylinder combined. With equipments now in general use this ratio must necessarily decrease as the size of the car increases because the brake-pipe volume remains practically constant for all sizes of cars, while the brake-cylinder and auxiliary reservoir volumes increase as the size of the car increases. It then follows that where air from the brake pipe alone is used to augment the brake-cylinder pressure in emergency applications, the emergency pressure thus obtained must vary with the different combinations of auxiliary reservoir and brake cylinder necessary for different sizes of cars—the gain in pressure from this source over that obtained in full service equalization being greatest with the smallest sizes of auxiliary reservoirs and brake cylinders.

Hence, in choosing a brake-cylinder pressure on which to base brake calculations, that obtained in emergency, which was satisfactory where the brake cylinders were of such size that a uniform pressure was obtained in both service and emergency, is now excluded at the outset—from the standpoint of uniformity—since in the nature of the case it is not uniform for all weights of cars. This is for the reason that brake cylinders may vary from 6 inches to 18 inches diameter with correspondingly varying pressures in emergency. And if the braking power desired is based on a brake-cylinder pressure higher than can actually be obtained, then for lower cylinder pressures the brake is not so effective as it might be made, were the braking power based on the pressure actually obtained. The smaller cars which do obtain this pressure give the calculated braking power in emergency, but the heavier cars cannot, and there is a loss, both in uniformity of emergency action and possible efficiency.

On the other hand, for brake-pipe reductions less than sufficient to produce equalization, the cylinder pressures obtained are uniform, provided the other factors are uniform in value and the pressure at which the auxiliary reservoir and brake-cylinder equalize is supposed to be the same for all combinations of reservoirs and cylinders, with the same initial pressure. To obtain this uniformity it is only necessary to properly proportion the reservoir volume to the brake-cylinder volume for some standard piston travel. We then have a pressure base which will be constant when the other factors involved have their proper or standard values. It would seem that this is the basis to which all braking power calculations should be referred, for the reason that it is the nearest approach to a uniform and constant pressure obtainable under the wide range of conditions governing this choice. This adds to the standard enumerated in the preceding column, the following:

3. This brake-cylinder pressure must be the equalized pressure on the auxiliary reservoir and brake cylinder.

4. A predetermined ratio between auxiliary reservoir volume and brake-cylinder volume to produce this equalization must be adhered to.

The fundamental steps in designing a brake system for any given car may now be outlined as follows:

Given the light weight of the car the proper braking power per cent has been established from results of experiment and experience, and this enables the total brake-shoe pressure to be calculated.

Mechanical considerations fix the total leverage ratio between certain limits, the maximum and minimum values of which enable a maximum and minimum total brake-piston pressure to be calculated from the preceding.

This total brake-piston pressure depends upon the size of cylinder and pressure per square inch used as a basis. The pressure basis to be used should be that agreed upon as a universal standard, for such calculations as this, and, as has already been pointed out, uniformity requires that the equalization pressure (50 pounds per square inch), from the lowest standard brake-pipe pressure carried, should be the base chosen.

Having determined the unit pressure, the size of cylinder can be chosen from the standard sizes manufactured to give the desired braking power with a total leverage within the maximum and minimum limits as defined above.

To obtain the desired 50 pounds equalization pressure from the standard 70 pounds brake-pipe pressure with a standard piston travel, is simply a matter of correctly proportioning the auxiliary reservoir volume to that of the brake cylinder at the piston travel employed as standard.

We then have an auxiliary reservoir which, at 70 pounds initial pressure, will equalize with its brake cylinder, when this has eight inches piston travel, at 50 pounds, and the brake-cylinder piston is of such an area that the total pressure thus obtained, when multiplied by the total leverage, will give a total brake-

ho pressure equal to the desired percentage of the weight of the car.

To be sure, in an emergency application, the braking power on all cars will be greater than that used in the design, and the lighter the car the greater the variation between service and emergency braking powers. But such non-uniformity in actual service is bound to obtain, and always has, since an increase to 90 pounds brake-pipe pressure, or a variation in piston travel produces similar results, to say nothing of losses due to leakage, resistances and variation in frictional coefficients. The advantage gained, however, by the method of design outlined is, therefore, in the fixing of a uniform and actually obtainable brake-cylinder pressure, which is necessary for service operations and is one of the most important factors in the calculation to be made.

It may be said in passing that with the more recent types of brake equipments for passenger service, using a supplementary reservoir volume, in addition to that of a brake pipe to produce high emergency brake-cylinder pressure, the size of supplementary reservoir used is calculated to give practically uniform brake-cylinder pressures in emergency applications with all sizes of brake cylinders, thus taking advantage of the principle of high pressures for emergency stops and at the same time conforming to the principles of uniformity laid down above, it being a fundamental principle of modern brake design to keep the service equalization brake-cylinder pressure comparatively low, for reasons fully explained elsewhere, and use as high an emergency equalization pressure (as large a supplementary reservoir) as may be desirable.

In the attempt to secure a high emergency brake-cylinder pressure without the aid of the supplementary reservoirs referred to above, the relationship between brake cylinder and auxiliary reservoir volumes existing in the original brake design was gradually lost; the auxiliary reservoir volume being increased slightly, from time to time, as heavier cars, requiring larger brake cylinders, were equipped. On the lighter equipment the variations thus introduced were relatively unimportant, but in the case of heavy cars, requiring the 16-inch and 18-inch cylinders, it was impossible to increase the auxiliary reservoir volume sufficiently to obtain the desired emergency pressure, without at the same time interfering to a marked degree with the proper operation of the equipment in service. Consequently, a compromise was made, so as to obtain as high an emergency cylinder pressure as possible without increasing the service equalization pressure to an extent inconsistent with the proper normal functions of the brake.

By the aid of a supplementary reservoir volume, however, reserved during service operation, but available in emergency applications of the brake, it is now possible to obtain the required increase in stopping power for emergencies and at the same time return to the original volume relationship, the correctness of which has been established by long experience.

These relationships are determined by the following principles, which will be recognized at once as having been followed in even the earliest automatic-brake designs:

(A) For any given arrangement of leverage between the brake-cylinder piston and the brake shoes, the "braking power" is directly proportionate to the gage pressure of air produced in the brake cylinder.

(B) The limitation of the maximum allowable pressure of air in the brake-pipe limits thereto the available pressure in the auxiliary reservoirs.

(C) With this fixed maximum charge in the reservoir, the highest pressure obtainable in the brake cylinder from this single source is that at which the air pressure equalizes between the two. This (absolute) pressure, therefore, equals the product of the initial absolute pressure in, and the volume of the auxiliary reservoir divided by the sum of, the volumes of the auxiliary reservoir and of the brake cylinder (neglecting all clearance volume, temperature effect, etc.), and the "braking power" is as the corresponding gage pressure.

(D) This pressure of equalization should be limited because its height determines the range of those differences between final auxiliary reservoir pressure and initial brake-pipe pressure, which range affords the control of "braking power" applied.

(E) That while low pressure of equalization limits "full service" pressure, yet small range precludes nicety of control, especially as from the range there must be deducted such initial differences of pressure as are necessary to overcome the inertia and friction of the triple valve parts.

(F) That to afford heightened brake-cylinder pressure for use in emergency another quantity of air is necessary, and if this be, as in all past practice, that contained in the brake pipe, the resulting absolute pressure will be equal, theoretically, to the maximum absolute brake-pipe pressure multiplied by the volume of the auxiliary reservoir plus the amount of air,

in cubic-inch pounds, obtained from the brake pipe, this sum then divided by the volume of the auxiliary reservoir plus that of the brake cylinder, so that the measure of the resulting braking pressure is the gage pressure corresponding to this resulting (absolute) pressure.

Now, it is the interdependence and reactive results of these simple and recognized principles in their combinations together with a corresponding proportioning of leverage between the brake-cylinder piston and the brake shoes that determine the relative efficiency of a brake design.

From (F) it is seen that if other parts be enlarged the volume of the brake pipe, which is practically the same on all cars, becomes relatively small and the emergency pressure sought is so insufficient that in the equipments for heavy rolling stock resort has been had to enlarged auxiliary reservoirs with a corresponding heightening of the "full service" pressure (C), and a resulting lessening of the range of control (D).

Again when (C) is heightened while (D) is lowered, the results of the lighter brake-pipe reductions cause magnified effects in the service braking, so that, when it is realized that such range as is possible is lessened by the lack of sensitiveness of the triple valve (E), there is likelihood of roughness of service stops.

Such being the case, it is apparent:

1. That there is a ratio of volume of auxiliary reservoir to that of brake cylinder that should not be exceeded.

2. That such service pressures as result in the brake cylinder should be made sufficient by a corresponding proportioning of the leverage.

3. That the volume of each car's part of the brake pipe should be supplemented by proper means so as to afford the required braking pressure in emergency.

Starting, therefore, with a brake cylinder of the size dictated by the vehicle to be equipped, as already explained, and by a proportioning of the leverage which shall accord with the service required, and assuming that—

$C$  equals volume of brake cylinder, in cubic inches;

$P$  equals service equalization pressure, in absolute units;

$R$  equals volume of auxiliary reservoir, in cubic inches;

$a$  equals absolute initial pressure in the auxiliary reservoir;

$r$  equals permissible range of brake pipe reductions;

it follows first, from the above definitions, that

$$r = a - P$$

and from (C) above, neglecting clearance volumes:

$$\frac{a \times R}{R + C} = P$$

from which

$$\begin{aligned} \frac{P}{a - P} &= \frac{R}{C} \\ \frac{P}{a} &= \frac{R}{C} \times \frac{P}{a - P} \\ &= \frac{R}{C} \times \frac{P}{r} \end{aligned}$$

which may be expressed in the following law:

The proper auxiliary reservoir volume, according to the principles laid down above, is equal to the volume of the brake cylinder determined upon multiplied by the ratio of the service equalization pressure fixed upon as standard to the permissible range of brake-pipe reductions.

Assuming, as in current practice, that  $P$  equals 50 pounds per square inch (gage) and  $a$  equals 70 pounds per square inch (gage), then we have

$$r = a - P = 20 \text{ pounds,}$$

and

$$\begin{aligned} \frac{P}{R} &= \frac{a}{C} \times \frac{P}{r} \\ \frac{50}{R} &= \frac{70}{C} \times \frac{50}{20} \\ &= 3\frac{1}{2} \times \frac{C}{R} \end{aligned}$$

That is, the volume of the auxiliary reservoir should be three and a quarter times the volume of the brake cylinder. It is plain, however, that the effect of the clearance volumes, leakages, temperature, and other adverse influence, will be such that to obtain the desired results in actual service a somewhat higher auxiliary reservoir volume must be used than that found by the above calculations. For example, with the standard 8-inch equipment, an auxiliary reservoir volume of 1,620 cubic inches is used, which is about three and one-half times the brake-cylinder volume.

In determining the proper size of supplementary reservoir (F) to be used, a similar reasoning may

be used. In addition to the symbols already defined, let

$S$  = volume of supplementary reservoir in cubic inches.

$E$  = absolute emergency equalization pressure.

Assuming for the purposes of calculation that the emergency pressure is the result of the equalization of the brake cylinder, auxiliary reservoir and supplementary reservoir volume, it follows that

$$\frac{a(R + S)}{R + S + C} = E$$

whence, by proper substitution and reduction, is derived

$$S = \frac{a(E - P)}{r(a - E)} \times C$$

While the above expression is interesting as showing the simple relation which exists between the various volumes involved in the typical equipment as we have assumed it, it must be clearly understood, first, that all the additional air supply in emergency is supposed to come from the supplementary reservoir, having taken no account of that vented from the brake pipe; and second, that in any actual installation similar to that discussed, the equalization is dependent upon the movement of certain valves actuated by spring and air pressures in combination, the resultant effect of which is such that in the actual working equipment the state of affairs is by no means as simple as has been assumed for the typical equipment. Instead of equalization taking place between all the volumes concerned simultaneously, there are time limitations imposed on the rate of flow from the various sources of air supply to the brake cylinder, so as to derive the maximum possible benefit from the compressed air stored in each. There is also a material modification of these calculated results, due to the processes not being truly isothermal, as assumed, and so on. Proper allowance being made for these limitations, a formula might be derived, in the same manner as above, to completely cover the more complicated conditions, but as only the principles involved are now being considered it is unnecessary to go further into details, particularly as these are accurately determined by experiment.

In the above analysis, as is necessarily the case with all theoretical considerations relative to mechanical apparatus of this character, certain assumptions were made to furnish a basis from which to start. Hence, it should always be remembered that the formulae derived must be interpreted, for any given case, in the light of the modification of these primary assumptions which the nature of the installation or the character of the apparatus used, may involve. With this understanding, the above reasoning affords a logical and sound theoretical basis, not only for determining the correct proportions of new types of equipment, but also establishes a criterion, by means of which the shortcomings of incorrectly designed installations may be discovered.

#### BRAKES FOR ELECTRIC TRACTION SERVICE.

It would hardly be proper to conclude without mentioning the fact that the electric traction service has required even more specialized apparatus than that already mentioned in connection with steam-road service on account of the great variety of conditions under which electric cars operate from the single city street car up to the eight and ten-car subway and elevated trains, to say nothing of the electric locomotive and multiple unit train service on electric division or steam railroads. It can easily be appreciated that these phases of the subject are of even greater magnitude and require a greater variety of apparatus and complexity of detail than in the case of steam-railroad service. Consequently, no more can be said at this time than to simply state the fact that the multiplicity of requirements has been anticipated and provided for to the extent that the high standard of efficiency already outlined has been maintained without any compromise or failure to meet the requirements of the service. In one particular, at least, the highest type of brakes, for electric service, namely, the Electro-Pneumatic System, affords superior stopping power and service efficiency, since its electric transmission of quick action insures simultaneously and almost instantaneously maximum braking power on all cars in the train, while for service braking, it possesses the maximum flexibility of control, possible only in an electrically actuated brake system. This brake, therefore, possesses superior features which are particularly noteworthy, whether they are considered from the standpoint of the time saved, the increased traffic made possible, or the safety insured. At the present time this type of equipment appears to be the acme of the braking art, but as past experience has always shown, the same time which brings about changes in operating conditions is also sure to develop new and more efficient means for meeting new requirements.

# Saving Human Life in Mines

## The Work of the United States Bureau of Mines

A LIFE-SAVING service for the rescue of miners in time of disaster is the first important step taken by the United States Bureau of Mines in its effort to reduce the appalling loss of life in American coal mines.

Six specially constructed cars fully manned by a corps of miners trained in rescue work and equipped with the latest rescue apparatus and first aid to the injured appliances have been located in the midst of the great coal districts in different sections of the country. These cars are ready at a moment's notice to proceed to the scene of a disaster, where the rescue corps, in co-operation with the state mining officials, do everything possible to save entombed miners.

During the year 1909 there were 2,412 miners killed in the coal mines and 7,979 injured. In the

given by the mining engineer attached to the car. The mine rescue cars go to the miner in his own town or camp, so there is little excuse for the miner not benefiting himself. Each car has a specified territory, and it is expected that every community of any importance will be visited. In addition to a mining engineer, a surgeon of the American Red Cross accompanies each car. The lectures delivered touch upon the use of explosives, electrical equipment, fire prevention, sanitation and first aid to the injured surgical treatment. When a suitable meeting place cannot be secured the lectures are given in the cars. The itineraries are so planned that the cars remain long enough at each place for the miners to go through the training in rescue work, which is in charge of the foreman of the car, a practical miner.

Had it been possible to reach these men within a few hours their lives might have been saved.

Every effort is made to encourage the miners to form rescue corps at the mines where they are employed and to have the operators equip them with the rescue apparatus. As a result of the educational work along this line, numerous coal operators throughout the country have purchased mine rescue equipment. For instance, according to the annual report of the State Inspector of Coal Mines of Washington, eleven companies have purchased thirty-one pieces of the Draeger rescue apparatus during the past year.

The bureau has already trained more than five hundred men in rescue work and first aid to the injured. It expects to train upward of three thousand men a year. Each man taking the training receives



THE OXYGEN HELMET

coal and metal mines it is estimated that 3,000 men were killed and 10,000 were injured in 1909. For every 1,000 men employed from three to five men are killed each year in the mines of the United States. In foreign countries from one to two are killed in each 1,000 employed. In those European countries where the deaths are least per 1,000 men employed rescue apparatus has been in use for some time, and it is with the hope that European conditions can be approached that rescue apparatus is being introduced here.

The saving of human life is the emergency feature of a general campaign of educational work among the miners, who are not only taught the use of rescue apparatus, but also the proper way to care for an injured miner. Lectures on different phases of the mining problem looking toward greater safety are

The cars contain eight small oxygen helmets, a supply of oxygen in tanks, one dozen safety lamps, one field telephone with 2,000 feet of wire, resuscitating outfits, and a small outfit for use in demonstration and actual practice of equipment relating to first aid to the injured in connection with mine accidents.

One end of the cars is fitted up as an air-tight room to be used in training men in the use of the small oxygen helmet. This room is filled with noxious fumes, and the miners, wearing the helmets, remain inside for two hours in an atmosphere that would kill without the helmets. These are the helmets that permit one to enter a mine immediately following an explosion while it is still filled with poisonous gases, and breathe artificially.

The absence of the helmets at great catastrophes in the United States has, it is believed, resulted in greater loss of life than necessary. Frequently miners who have not suffered physical injury by an explosion have been entombed in the mine to die solely from the inhalation of the poisonous gases.

a certificate. The certificates are highly prized by the men and are usually framed and exhibited with great pride. A large percentage of those who have taken the training have announced their intention of again taking it at the expiration of six months or a year. They are all thoroughly trained in the use of the oxygen helmet and practically promise to be volunteers at any accident that occurs in their territory. If the rescue car is near, it will pick up these men on its way to the disaster. Perhaps as a result of the rescue work of the bureau nearly one hundred coal companies have equipped themselves with complete rescue stations, whereas in the past they not only had no trained rescuers, but had no apparatus to enter a mine.

Past experience has been that in every big mine disaster a great many of the volunteer rescuers themselves have been killed. At one mine disaster, with seventy men killed, fifty rescuers were among the number. In the famous Cherry Mine disaster twelve men who went down as rescuers were brought up

## The United States of America. BUREAU OF MINES

DEPARTMENT OF THE INTERIOR

### Certificate of Mine Rescue Training

This is to certify that \_\_\_\_\_ of \_\_\_\_\_  
has been trained in the use of MINE RESCUE APPARATUS at the Government Mine Rescue Station  
at \_\_\_\_\_ during which training he performed hard labor  
within a gallery filled with noxious and irrespirable gases and gave evidence of being  
qualified to care for and use such apparatus within mines.

Trained under the direction of \_\_\_\_\_

Approved: \_\_\_\_\_

Washington, D. C. 191 \_\_\_\_\_

PERSONS HOLDING THIS CERTIFICATE SHOULD UNDERTAKE ADDITIONAL TRAINING EVERY SIX MONTHS TO KEEP IN PROPER CONDITION OF EFFICIENCY

CERTIFICATE ISSUED BY THE UNITED STATES BUREAU OF MINES



THE IMPROVED AMBULANCE CAR



A HOSPITAL CAR FOR MINE USE

SAVING HUMAN LIFE IN MINES

dead on the cage. The death of rescuers has swelled the deaths of men killed in the mines. Since the Bureau of Mines has been established only two helmeted men or rescuers have been killed in mines.

There has never been any question as to the bravery of the miners in time of disaster. The only trouble has been the recklessness displayed. The miners have never hesitated to rush into danger in order to save a fellow worker, and that is the reason so many have been killed. A very large percentage of the rescuers

have met death owing to lack of proper equipment. For example, recently in a Pennsylvania mine some trouble was experienced and the superintendent and half a dozen of the best men went down to ascertain what the trouble was. They got in and were overcome, but one of the number managed to telephone to the top. Several helmeted men went in and rescued them. If it had not been for the use of the helmet in this instance the men would have been killed. In a recent mine disaster in Ohio where a large num-

ber of fatalities resulted two men, having been overcome, lay along the floor of the working and had been passed by the rescuing parties for nearly twenty hours. One of the engineers of the bureau, noticing them, felt under the arm pits and found a slight warmth. The pulmotor was used and the men resuscitated. To-day these men are alive and working, whereas, if it had not been for the application of the pulmotor, they would have expired within a short time.

## Eagle Hunting in China

### A Lucrative Oriental Sport

EVERY year, according to an old custom, in the second quarter of the September or October moon, the inhabitants of the Chinese province of Shantung go to Mongolia to hunt the eagles which abound in that region strewn with many bodies of animals and even of men. The huntsmen march in troops along the roads, carrying on their shoulders long poles from which are suspended their baggage and provisions, and on which are perched tame eagles to be used as decoys. Commandant Laribe, encountering such a procession, obtained the photographs which are here reproduced from *L'Illustration*, from which we also take the details given below.

The hunters make use of a large net, laid flat on the ground, and baited with small dried fishes, in the midst of which is placed the tame eagle. The decoy naturally begins to devour the bait and thus invites his wild cousins to follow his example. When the birds have alighted and are feeding, the hunter, from his hiding place, two or three hundred yards distant, quickly closes the net by means of a system of cords and thus captures the eagles.

Eagle hunting is very lucrative; the feathers are used in the manufacture of fans and are sold at a high price even in China.

There are three sorts: Kie-pel, black with white centers; Che-ma, white spotted with black; Tou-tsing, half white and half black. Several eagles are required to make a fan, for only a small part of the plumage can be utilized. Hence these fans are very costly. A fan made of Kie-pel feathers may cost as much as fifty taels, or about thirty dollars. A fan of Che-ma feathers is worth thirty taels. Fans made of the feathers which do not belong to any of the three sorts named are worth only a few taels. This information was obtained from a native of Kalgan on the Mongolian frontier; it is therefore probably correct.

#### Up-to-Date Pearl Diving

ONE by one industries of various kinds, about which for centuries there has clung the atmosphere of romance, are losing their glamor, by reason of the advancement of practical science. For instance, pearl diving. The era of naked divers exposed to peril from sharks has passed away; modern progress equips the pearler with a suit of India rubber, copper breastplate, with leaden weights back and front; helmet, glass panelled and with telephonic attachments; air pipes, life lines and a submarine searchlight. Thus furnished forth, the pearl diver may spend six or eight hours at the bottom of the sea, whereas in other times three minutes made a record.

Although pearls are found in nearly all molluscs and even in univalves, like the Australian ballotis, a kind of barnacle, true pearls are produced only by the pearl oyster or mother of pearl shell. The latter is really the diver's bread and butter. The shells are nearly as large as a dinner plate and weigh two pounds when cleaned. They fetch from \$500 to \$750 a ton.

The ancient fisheries were chiefly in the Indian Ocean and Persian Gulf, but nowadays the best pearls come from Ceylon and from Australian waters, especially Torres Straits. Pearl fishing in Ceylon is a government monopoly. In March the fleet starts for the pearling grounds, each vessel with twenty or thirty divers and their assistants. But the headquarters of pearling are to be found in the desolate country extending from Exmouth Gulf to King Sound, in Western Australia.

Chinese and Malays as well as tribes of native blacks are there to-day, but the old nude divers, the reign of terror and piracy where a large haul was made, these and similar conditions have passed away, giving place to fleets of luggers carrying modern diving outfits and representatives of capitalists in the person of the master pearlmen. Here is 600 miles of coast line, with perhaps 3,000 hardy adventurers engaged in the pearl trade.

There are some thousands of Japanese, Manila-

men, Malays and men of other races, acting chiefly as crews for the vessels. The vessels are schooner rigged and from seven to fourteen tons burden. Each carries a master diver and a crew of four, one of whom is the diver's assistant and works the air pumps.

The shells are found on ledges about ninety feet



TAME EAGLES USED AS DECOYS

down in the sea, but they are far more plentiful at greater depths. Fortune awaits the inventor of a diving apparatus that will enable the pearler to work in comfort a hundred fathoms down.

A good day's work is anything more than 200 pairs of shells. The business is absolutely speculative. One diver may gather ton after ton of shells without securing anything of greater value than a few seed pearls, while another may take a fortune out of a day's gathering.

The most famous pearl discovered in Australia of late years is known as the Southern Cross. It consists of a cluster of nine pearls in the shape of a cross. This freak of nature was picked up at low water on the Lacpede Island by a beach comber, who, after burying it for some time for superstitious reasons, sold it for \$50. It afterward brought \$50,000.

The worst enemy the Australian pearl divers have are the storms that annually visit the coast. As to sharks, they rarely attack a diver in modern dress, and he can always frighten them off by letting a few

air bubbles out of his dress. Other enemies are the sea snakes, the smaller octopi, the stringray and the blowfish.

After a day's take of shell has been conveyed ashore the shell opener begins work at once. The pay of the men is \$30 a month, plus ten per cent on the value of the pearls found. Some idea of the magnitude of the industry may be obtained on learning that in one year five hundred and twenty luggers paid an annual five-dollar license to engage in the trade, and that they took many thousands of tons of pearl shell; while as to the pearls themselves, the customs duties in the pearl town of Broome exceeded \$5,000 a month.

The treasury authorities of Western Australia estimate that they receive at least \$100,000 a year in dues from the pearlmen. Hardly a month passes without the discovery of pearls having a market value of from \$5,000 to \$15,000 each. A beautiful pink pear-shaped specimen weighing two hundred and six grains was found last season and sold for \$80,000.

Before setting, pearls are classified according to size on a setting board, and the delicate work of drilling a valuable specimen is invariably done by an old-fashioned hand apparatus. Moreover, no matter how valuable a set of pearls may be they are invariably strung on fine silk thread.

Inland pearl fishing forms no mean industry in this country. Although pearls have been gathered from the fresh water mussels of our country as far back as the time of the aborigines, yet the hunt for them did not become systematic and general until shortly after the middle of the last century. Since then nearly every stream east of the Rockies has been prospected in the search for these valuable parasites of the pearl mussel.

One of the finest pearls ever secured in the fresh waters of the United States was found in Notch Brook, near Paterson, New Jersey, in 1857. It weighed ninety-three grains. Subsequently it became known as the Queen pearl, and was sold for \$2,500 to the Empress Eugenie. Owing to the great increase in the value of pearls in recent years, it is now worth more than five times that amount.

Shortly after the year mentioned what was probably the largest pearl ever found in these waters was taken in the same brook. In shape it was round, and weighed over four hundred grains; but unfortunately



CHINESE EAGLE HUNTERS ON THE MARCH

the pearl was ruined by the crude method of boiling them employed to open the shells.

During the pearl excitement near Waynesville, Ohio, in 1876, a few extraordinarily good pearls were found. One, button-shaped on the back, weighing thirty-eight grains, was the gem of the collection. In the early eighties a sky-blue pearl which was found in Caney Fork, Tennessee, was sold for \$950, and subsequently brought \$3,300 in London.

During the summer of 1889 a quantity of magnificently colored pearls were found in creeks and rivers of Wisconsin. One of these pearls sold for over \$500, and some among them were equal to any ever found for beauty and coloring.

The year 1807 saw the pearling craze break out in Arkansas. A deep pink pearl of forty grains weight was found in the mud of one stream by a woman, while a farmer's boy obtained a pink pearl

of thirty-one grains in Black River and sold it for \$35, the purchaser disposing of it in St. Louis a little later for \$500.

In 1898 a fisherman searched the head waters of the Mystic River in Connecticut, and, after a few week's work, gathered a number of pearls, one of which he sold for \$500 and two for \$400 each.

The best price ever received by a finder for an American fresh water pearl was \$10,000 for one from Tennessee. Two others from the same State brought \$650 and \$1,000 each. A Wisconsin pearl sold for \$8,000 dollars, while two Florida pearls of sixty-eight and fifty-eight grain brought \$850 and \$600, respectively.

A year or so ago there was offered for sale by a gem dealer of New York a perfect pearl, white and rounded, weighing sixty-eight grains, which he valued at \$15,000. This pearl was found near the Wis-

consin bank of the Mississippi River, and was sold by the finder, who evidently had not the slightest idea of its value, for seventy-five cents. Another pearl, found about the same time, was recently offered for sale in New York for \$5,000. The latter is a pink, pear-shaped pearl and weighs ninety-nine grains.

A few years ago a fisherman became so agitated on finding a pearl the size of a pigeon's egg in a mussel that he dropped it into the water and it was never recovered.

Many odd-shaped pearls are found. One was found in this country that strikingly resembled the bust of Michelangelo. In a few instances small fishes, crabs, and insects which entered the shell have been imprisoned and covered eventually with nacre, thus making pearls of them, at the same time retaining the animal's shape.

## Charles Darwin\*

### The Justification of the Darwinian Theory

By August Weismann

Forty-one years ago, when I delivered my inaugural address as a professor of this university, I took as my subject "The Justification of the Darwinian Theory." It is a great pleasure to me to be able to lecture again on the same subject on the hundredth anniversary of the birth of Darwin.

This time, however, I need not speak of justifying the theory, for in the interval it has conquered the whole world. Yet there remains much that may be said—much, indeed, that ought to be said at the present time. In my former lecture I compared the theory of descent or evolution to the Copernican Cosmogony in its importance for the progress of human knowledge, and there were many who thought the comparison extravagant. But it needs no apology now that the idea of evolution has been thoroughly elaborated, and has become the basis of the science of life.

You know that Darwin was not the only one, and was not even the first, to whom the idea of evolution occurred; it had arisen in several great minds half a century earlier, and it may therefore be thought an injustice to give, as we now do, almost all the credit of this fruitful discovery to Darwin alone.

But history is a severe and inexorable judge. She awards the palm not to him in whose mind an idea first arises, but to him who so establishes it that it takes a permanent place in scientific thought, for it is only then that it becomes fruitful of, and an instrument for, human progress. The credit for thus establishing the theory of evolution is shared with Charles Darwin only by his contemporary, Alfred Russel Wallace, of whom we shall have to speak later.

Nevertheless, a reflection of the discoverer's glory falls upon those who, about the end of the eighteenth and the beginning of the nineteenth century, were able to attain to the conception of evolution, notwithstanding the incomparably smaller number of facts known to them. As one of these pioneers we must not omit to mention our own poet, Goethe, though he rather threw out premonitory hints of a theory of evolution than actually taught it. "Alle Gestalten sind ähnlich, doch keine gleichet der andere, und to deudet der Chor auf ein geheimes Gesetz."

The "secret law" was the law of descent, and the first to define this idea and to formulate it clearly as a theory was, as is well known, also a Darwin, Charles Darwin's grandfather, Erasmus, who set it forth in his book, "Zoonomia," in 1796. A few years later Treviranus, a botanist of Bremen, published a book of similar purport, and he was followed in 1809 by the Frenchman, Lamarck, and the German, Lorenz Oken.

All these disputed the venerable Mosaic mythos of creation, which had till then been accepted as a scientific document, and all of them sought to show that the constancy of species throughout the ages was only an appearance due, as Lamarck in particular pointed out, to the shortness of human life.

But Cuvier, the greatest zoologist of that time, a pupil of the Stuttgart Karlschule, would have none of his idea, and held fast to the conception of species created once for all, seeing in it the only possible explanation of the enormous diversity of animal and plant forms.

And there was much to be said for this attitude at that time, when the knowledge of facts was not nearly comprehensive enough to afford a secure and scientific basis for the theory of descent. Lamarck alone had attempted to indicate the forces from which in his opinion, the transmutation of species could have resulted.

It was not, however, solely because the basis of fact was insufficient that the theory of the evolution of organic nature did not gain ground at that time; it was even more because such foundation as there was for it was not adhered to. All sorts of vague speculations were indulged in, and these contributed less and less to the support of the theory the more far-reaching they became. Many champions of the "Naturphilosophie" of the time, especially Oken and Schelling, promulgated mere hypotheses as truths; forsaking the realm of fact almost entirely, they attempted to construct the whole world with a free hand, so to speak, and lost themselves more and more in worthless phantasy.

This naturally brought the theory of evolution, and with it "Naturphilosophie," into disrepute, especially with the true naturalists, those who patiently observe and collect new facts. The theory lost all credence, and sank so low in the general estimation that it came to be regarded as hardly fitting for a naturalist to occupy himself with philosophical conceptions.

This was the state of matters onward from 1830, the year in which the final battle between the theory of evolution and the old theory of creation was fought out by Geoffroy St. Hilaire and Cuvier in the Paris Academy. Cuvier triumphed, and thus it came about that an idea so important as that of evolution sank into oblivion again after its emergence, and was expunged from the pages of science so completely that it seemed as if it were for ever buried beyond hope of resurrection.

Scientific men now turned with eagerness toward special problems in all the domains of life, and the following period may well be characterized as that of purely detailed investigation.

Great progress was made during this period; entirely new branches of science were founded, and a wealth of unexpected facts was discovered. The development of individual organisms, of which little had previously been known, began to be revealed in all its marvelous diversity; first, the development of the chick in the egg; then of the frog; then of insects and worms; then of spiders, crustaceans, starfishes, and all the classes and orders of mollusks, as well as of backboneed animals from the lowest fish up to man himself. Within this period of purely detailed investigation there falls also the discovery, in animals and plants, of that smallest microscopically visible building stone of the living body, the cell, and this discovery paved the way for the full development of the newly founded science of tissues, histology.

In botany the chief progress in this period was in regard to the reproduction and development of the lower plants, or cryptogams, and the discovery of alternation of generations, a mode of reproduction that had previously been known in several groups of the animal kingdom, in polyps and medusae, in various worms, and later in insects and crustaceans.

At the same time it was found that the proposition, which had hitherto been accepted as a matter of course, that an egg can only develop after it has been fertilized, is not universally valid, for there is a development without previous fertilization—parthenogenesis, or virgin birth.

Thus, in the period between the Napoleonic wars and 1859, an ever increasing mass of new facts was accumulated, and among these there were so many of an unexpected nature that further effort was constantly being put forth to elucidate detailed processes in every domain. This was desirable and important—was, indeed, indispensable to a deeper knowledge of organic nature. But in the endeavor to investigate details naturalists forgot to inquire into the deeper causes and correlations, which might have enabled

them to build up out of the wealth of details a more general conception of life. So great was the reaction from the unfortunate speculations of the so-called "Naturphilosophie," that there was a tendency to shrink even from taking a comprehensive survey of isolated facts, which might lead to the induction of general principles.

How deep was the oblivion into which the philosophical conceptions of the beginning of the century had sunk by the middle of it may be gathered from the fact that in my own student days in the fifties I never heard a theory of descent referred to, and I found no mention of it in any book to which I had access. One of the most famous of my teachers, the gifted anatomist, J. Henle, had written as a motto under his picture, "There is a virtue of renunciation, not in the domain of morality alone, but in that of intellect as well." This sentence was entirely obscure to me as a student, because I knew nothing of the intellectual excesses of the "Naturphilosophie," and I only understood later, after the revival of interest in general problems, that this insistence upon the virtue of intellectual renunciation was intended as a counteractive to the over-speculations of that period.

This was one-sided, but it was a necessary reaction from the one-sidedness in the opposite direction which had preceded it.

The next swing of the pendulum was brought about by Charles Darwin in 1859 with his book on "The Origin of Species."

Let us now consider the development of this remarkable man, and note the steps by which he attained to his life work. Charles Darwin was born on the 12th of February, 1809, the same year in which Lamarck published his "Philosophie Zoologique." But he had not sucked in the doctrines of that evolutionist, or of his own grandfather, Erasmus Darwin, with his mother's milk. His youth fell within the period of the reaction from philosophical speculation, and he grew up wholly in the old ideas of the creation of species and their immutability. His birthplace was the little town of Shrewsbury, near the borders of Wales, where his father was a highly respected physician, well to do even according to English standards.

If we think of Charles Darwin's later achievements we are apt to suppose that the bent toward natural science must have been apparent in him at a very early age, but this was not the case, at least not to a degree sufficient to attract the attention of those about him. It is easy now, of course, to say that the pronounced liking for ranging about wood and field and collecting, quite unscientifically, plants, beetles, and minerals, foreshadowed the future naturalist. Even as a boy Darwin was an enthusiastic sportsman and an excellent shot, and the first snipe he brought down excited him so much that he was hardly able to reload.<sup>1</sup> But he must have been not merely a sportsman but an eager observer, especially of birds, for at that time he wondered "in his simplicity" that every gentleman was not an ornithologist, so much was he attracted by what he observed of the habits of birds.

The school which he began to attend at Shrewsbury in his ninth year was probably very similar to our earlier gymnasias. Darwin himself maintained that nothing could have been worse for his intellectual development than this purely classical school, in which

<sup>1</sup> I can say the same of myself for, although in my boyhood I did not shoot birds, I had a passion for butterfly hunting. When I saw the rare *Limenitis populi* resting on the ground in front of me for the first time, I became so excited that I could not at first throw my net, and when I did throw it, though my aim was usually very accurate, I struck the butterfly obliquely over the wing with the iron ring of the net. The traces of this awkward aim are visible on the wing to this day.

\* An address delivered at the University of Freiburg on the occasion of the Centenary of Darwin. Reprinted from *The Contemporary Review*.

nothing was taught, in addition to the ancient languages, except a little ancient history and geography.

Darwin had no talent for languages, and no pleasure in them. So he remained a very mediocre scholar, and his father therefore removed him from school in his sixteenth year, and sent him to the University of Edinburgh to study medicine.

The condition of the English universities at that time must have left much to be desired, for Darwin characterizes the majority of the lectures as terribly dull, and the time spent in attending them as lost. Moreover, anatomy disgusted him, and the tedium of the geological lectures repelled him so that he vowed never again to open a book on geology, a resolution which, happily, he did not adhere to.

In his student days, as in his school time, he roamed about in the open air, sometimes shooting, sometimes riding, sometimes making long expeditions afoot. But even then he was not a conscious observer of nature, not a naturalist, but rather a lover of the beauty of nature and a collector of all sorts of natural objects, though he collected still, as he had done at school, rather from the collecting impulse frequently characteristic of youth than from any real scientific interest. If he had had that interest his chief passion would not have been the shooting of birds. His friends even found him one day making a knot in a string attached to his buttonhole for every bird he succeeded in bringing down! Thus he must have been mainly a sportsman, a hunting fanatic whose chief desire was to bring down as many birds as possible in a day. However, this devotion to sport must have stood him in good stead later, especially on his great journey, for through it he not only acquired the technique of shooting, but he sharpened his naturally acute powers of observation.

He remained two years in Edinburgh and then entered the University of Cambridge. His father, who had observed his disinclination for medicine, proposed that he should study theology, and Darwin knew himself so little that he was quite willing to agree to the proposal. He examined himself very conscientiously to see whether he was able to subscribe to the dogmas of the Anglican Church, and he came to the conclusion that he could accept as truth every word that the Bible contained. This was certainly remarkable, and proves that the "Zoonomia" of his grandfather, Erasmus, and the doctrines of Lamarck, as far as he was acquainted with them, had not taken very deep root.

So he proceeded to study theology. But he did it much in the same way as he had studied medicine in Edinburgh; he listened only to what pleased him, and that can not have been very much, for here, too, he complained of the dullness of official lectures. Nevertheless, at the end of three years he passed his examination quite creditably and received the degree of B. A.

Of the greatest advantage to him in Cambridge was his intercourse with two distinguished teachers of the university, and this intercourse probably guided him imperceptibly toward the real work of his life. One of these teachers was Prof. Henslow, a theologian who afterwards accepted a living, but who had a comprehensive knowledge not only of entomology, but of chemistry, botany, mineralogy, and geology. By Henslow, Darwin was introduced to the professor of geology, Sedgwick, and he, too, interested himself greatly in the young man, taking him with him on his longer geological excursions, and thus giving him a most valuable introduction to the science. This proved of the greatest use to Darwin on his travels, and probably enabled him to make his numerous geological observations.

Other older men also admitted Darwin to their friendship, so that it is obvious that there must have

been something about him even then which distinguished him from others of his age. His interests now began to widen; he came under the educative influence of art, and studied the picture gallery in Cambridge, and later the National Gallery in London. He gained the entrance to a musical circle, and derived great pleasure from music, though, curiously enough, as he tells us, he was almost destitute of "ear," and could not even whistle "God Save the King" correctly. He was thus one of those rare persons who are exceedingly sensitive to the emotional effect of music and yet possess little or nothing of its physical basis, the sense of tone.

In addition to all this, Darwin retained his passion for beetles, and collected with such ardor that twenty years later he recognized at sight small rare species he had found under bark or moss at that time. His powers of observation had thus been awakened, although as yet they were employed mainly to minister to his zeal for collecting. But collecting is not a mere amusement for the young naturalist; it is a necessary discipline in surveying a definite range of forms, and it can not well be replaced by anything else. One who has never collected, and thus never made himself thoroughly acquainted with a limited circle of forms, will find it difficult to fill up the gap in his attainments in later life.

In vacation time toward the autumn of each year Darwin turned again with enthusiasm to sport, either at his home in Shrewsbury or on his uncle Wedgewood's large estate of Maer. He did not lose a possible day from this amusement, for as he says in his autobiography, "I should have thought myself mad to give up the first days of partridge shooting for geology or any other science." Thus, notwithstanding his interest in geology and beetle collecting, in pictures and music, the old passion for the chase was still the dominant one; one pleasure crowded upon another, and the whole made his life a joyous symphony, so that he could say of that period, "The three years which I spent at Cambridge were the most joyful in my happy life." But in the midst of all the joyousness of life he was undergoing an inward preparation for the seriousness of it. We can gather from his own account of that time that the strongest impulse toward the study of natural science came from reading two works which aroused his interest, Humboldt's "Personal Narrative" and Herschel's "Introduction to the Study of Natural Philosophy." Darwin says of these: "No other book influenced me so much as these two." He used to copy long passages from Humboldt about Tenerife and read them aloud to Henslow. He was very anxious to go to Tenerife, and even made inquiries in London about a ship to take him there, when an event happened which overthrew that project, but at the same time opened up the way to a naturalist's career—the only one really suited to him—in a much more satisfactory manner. He received a proposal to make a voyage round the world.

It must appear to us singular that a young man who had just finished his university course, and had done no scientific work of any kind, should be invited to accompany, as a naturalist, a naval vessel which was being sent round the world by the government for the purpose of making nautical observations. It proves that Darwin's older friends must have had very high expectations in regard to his future.

Capt. Fitzroy, of the English navy, was looking for a young man who would go with him as naturalist, on a voluntary footing, on his voyage in the "Beagle."

Darwin himself was at once eager to accept, but his father objected very decidedly, seeing no reasonable object in spending five years ranging over the globe. But he concluded his letter with the sentence, "If you

can find any man of common sense who advises you to go, I will give my consent."

The necessary adviser was found in his uncle, Wedgewood, who, as soon as he heard of the matter, immediately drove the 40 miles from Maer to Shrewsbury and persuaded the elder Darwin that he must allow his son to go.

Thus it happened that Darwin made the journey which he speaks of later as "the most important event of my life," as it undoubtedly was. It was only later that he learned that even then his going was not a certainty, for Capt. Fitzroy, after seeing him, was in doubt as to whether he should accept him, for a reason not easy to guess—because of the shape of his nose! Fitzroy was an enthusiastic disciple of Lavater, whose doctrine of physiognomy was then widespread. He believed that the shape of Darwin's nose proclaimed a lack of energy, and he was doubtful about taking anyone deficient in that quality on such a journey. Happily, Darwin's friends were able to reassure Fitzroy on this point, and he must often enough afterward have had opportunity to convince himself of Darwin's energy.

Thus it was apparently by mere chance that Darwin got the opportunity to develop actually into the great naturalist we now know that he must have been potentially. But I do not believe that this is a correct judgment. His inward impulse would certainly have forced a way after he had been led to perceive, through Humboldt and Herschel, what the way for him was to be. And even at that time no serious obstacle would be likely to stand in the path of a young Englishman of fortune who wished to explore foreign lands and seas. But undoubtedly this manner of traveling for five years through the seas and countries of the different zones was particularly advantageous.

And Darwin used his opportunities to the full. On board ship he studied the best books, especially Lyell's "Principles of Geology," but he also collected certain kinds of natural objects, and investigated all that came in his way, keeping a detailed journal of everything that struck him as worthy of note in what he observed. Thus he became a well-informed and many-sided naturalist. But he valued much more highly than any other result of the voyage the habits of energetic industry and concentrated attention to whatever he had in hand that he then acquired. And thus he became the great naturalist for which nature had designed him.

Darwin published his journal later; it fills a closely printed volume of 500 pages. Like all his books, it is characterized by a simplicity and straightforwardness of expression; there is absolutely no striving after sensational effect, but an innate enthusiasm and truth pervades it, and I have always found it most enjoyable reading. Other people must have found it so, too, for by 1884 16,000 copies of the English edition had been sold. I cannot here give even a brief account of the voyage of the "Beagle"; I can only say that its work lay chiefly on the southern coast line of America, and the journey included the east coast of Bahia to Tierra del Fuego, and the inhospitable Falkland Islands, and the western coast to Ecuador and Peru.

This occupied several years, and thus the young explorer had a chance to make himself thoroughly acquainted with a great part of the South American continent, for while the ship lay at anchor taking soundings in some bay or other, Darwin ranged over the country on horseback, in a boat, or on foot. In Brazil, on the plains of the La Plata River, and in Patagonia he made excursions into the interior which lasted for weeks, and he was thus able to see and investigate everything that interested him.

(To be continued.)

### Bienaimé's Proposed Ascension

M. MAURICE BIENAIMÉ is to make an interesting balloon ascension from Paris especially for meteorological and other scientific observations. Without wishing to break the record which was made by the Germant aeronautes Suring and Berson in 1901 at 10,800 meters (35,433 feet) altitude, he expects with a much smaller balloon of 1,600 cubic meters (56,502 cubic feet) of the usual touring size, to go higher than the 8,558 meters altitude (28,077 feet) reached by Balsan and Godard in 1900. Seeing that the aeroplane has not been used as yet for exploring the upper atmosphere to any extent, this must be done by sounding balloons of small size or by regular balloons mounted by an aeronaut. Such observations are more difficult to make than may be thought, seeing that the air pressure becomes much less, and is only one-half of the ordinary when we rise to 15,000 feet. This causes bleeding from the nose and ears and like disorders, while the rarefied air becomes difficult and even impossible to breathe. Intense cold is another

point, and it may reach 40 deg. below zero C., added to which is the "altitude sickness," so that the aeronaut is likely to become paralyzed or in a lethargic state, and this may even cause death. However, by using the proper precautions M. Bienaimé expects to make his ascension a success. The scientific commission of the French Aeronautic Club has laid out a programme for this occasion. The radio-activity of the atmosphere and the solar heat are to be observed.

As the air is always more or less a conductor of electricity, and its conductivity varies with the altitude, it is of interest to measure this at different heights. The value depends on the number of electrified particles or ions in a given amount of air. Experiments made on mountains are not of much value, as the electric charge follows the reliefs of the ground. From a practical standpoint the study of the distribution of these particles in the atmosphere is important in meteorology, seeing that it is now admitted that this is the cause of rainfall.

Besides, electric charges in the upper air allow of explaining the variations of terrestrial magnetism. Such variations are often very considerable, and cause disturbances which may interfere with telegraphs or telephones, as is well known. It is found that magnetic disturbances always coincide with the appearance of the aurora borealis. Apparatus will be carried on board for making observations in this field. For other work there will be used various kinds of instruments, such as a sphygmograph for registering arterial tension and a Mathieu instrument for measuring muscular force at different altitudes. Registering instruments of the Richard type will serve to make records of the temperature of the air and the moisture. Other recording devices will take the highest altitude which is reached, and make other measurements. M. Albert Senouque will have this work in charge, and he is well known for his researches in terrestrial magnetism during the Charcot expedition to the Antarctic regions, having also made researches at the Mont Blanc observatory.

# Reclamation of the Southern Louisiana Wet Prairie Lands—I\*

By A. D. Morehouse, Office Engineer, Drainage Investigations<sup>2</sup>

## INTRODUCTION.

In the conquest of the country the heavily timbered areas of the East have been subdued, the vast prairie lands of the Middle West have been settled, the riches of the west coast have yielded of their stores, the waterless regions of the Great American Desert have broken into verdure under the magic of irrigation, and "dry farming" has brought into productiveness

tunes by that river and its tributaries and deposited here by every recurring flood, they form now "the most fertile agricultural lands of the State, equaled by few and surpassed by none in the world in productive capacity," as described by Dr. Hilgard in writing of this region.

## FORMATION OF THE LANDS.

Recent borings to a depth of 3,170 feet in the

was deposited in the more slowly moving waters away from the main currents of the streams. This point, as well as the fact that the natural drainage is away from the river, is well brought out by the following from "A Preliminary Report Upon the Bluff and Mississippi Alluvial Lands of Louisiana," by W. W. Clendenin,<sup>3</sup> written a few years since:

"With every flood the river now overflows its flood

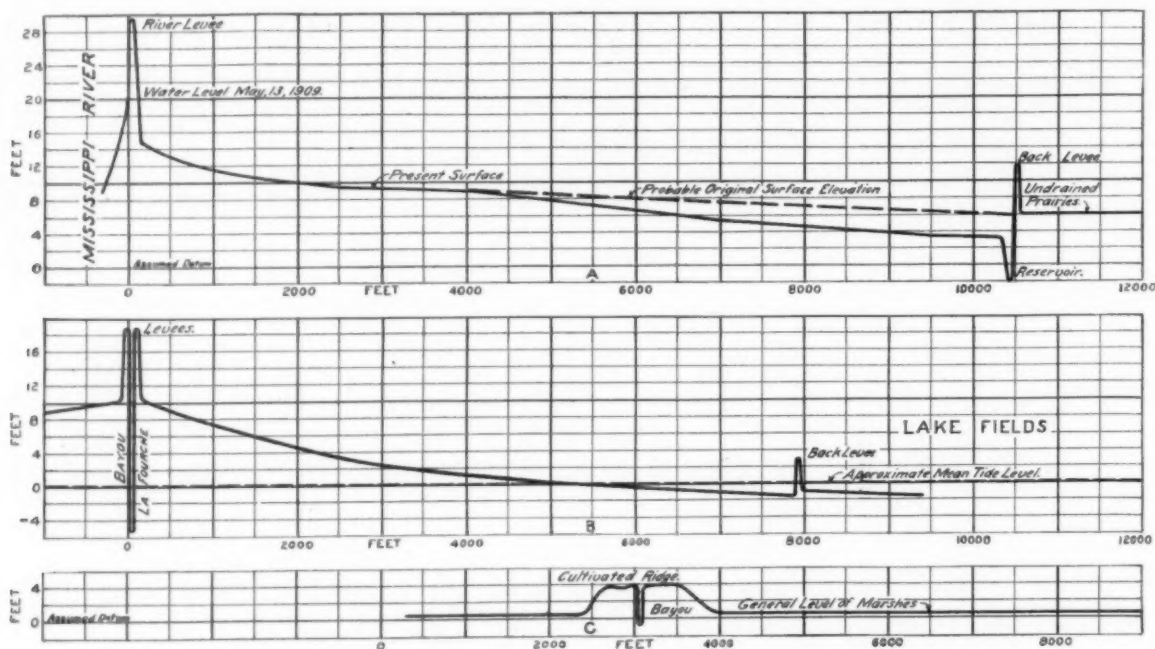


FIG. 1.—TYPICAL EXAMPLES OF LOUISIANA MARSH LAND FORMATION

A, profile through Willawood plantation; B, section through Smithport plantation; C, formation caused by small bayou near Lockport.

immense sections of land once considered worthless. However, throughout the space of the several centuries which have witnessed this wonderful development, one of the richest sections of the country's great domain has lain unused and unproductive; first, clothed in the mystery cast upon it by its Spanish ownership, and later, since its acquisition by the United States, associated in the minds of men with visions of pestilential swamps, deemed worthy only of neglect owing to the supposed difficulties of its reclamation, and never thought to be a region whose wonderful agricultural possibilities would test the credulity of men.

Within the last few years all this has changed and the alluvial prairie lands of southern Louisiana are coming into their own. Formed by the richest soils of the whole Mississippi Valley, brought down for cen-

vicinity of Houma have failed to penetrate this layer of sediment, and at a depth of 2,400 feet pieces of fairly preserved wood have been encountered. Owing to the fact that the soil is water-laid material, nothing coarser than river sand is encountered except the overlying layer of humus formed by the decaying vegetation. A typical section of these lands would show a layer of humus or muck 2 or 3 feet thick overlying a grayish or drab clay subsoil composed of very fine particles, which when saturated form a tough, impervious mass. Layers of sand of varying thickness are encountered in this clay subsoil, and occasionally no clay stratum intervenes between the humus and sand. The surface soil is from a few inches to 5 feet or more in thickness.<sup>1</sup>

## NATURAL LEVEES.

The embankments or natural levees along all the bayous and streams with which this region abounds, and those along the Mississippi, are formed by the constant overflows. They are composed of coarser sand than the clay subsoil of the prairies, as this latter

plain and deposits much of the sediment from its headwaters. As with a slight increase in velocity the transporting power is vastly increased, so with a slight checking of velocity, as occurs over the flood plain outside of the channel, deposit takes place. As the greatest decrease in velocity takes place near the channel, there the heaviest and coarsest sediment is deposited, and in greatest quantity. The river banks are thus built higher by each flood, and a system of natural levees is produced. There is thus a marked difference in the "front lands" and the "back lands" along the river. The former are higher and coarser textured than the latter, and therefore much more easily cultivated and drained.

"Drainage from the very channel margin is away from the river, and, unless forced by the topography of the land, will not reach the river proper, but unite with some outlet of the river produced during some extraordinary flood period and kept open by the escape of water during ordinary periodic flood stages. As the feeders of the river are called tributaries, these

\* This article is based on reports to the chief of drainage investigations, by A. M. Shaw, C.E., New Orleans, La., and Prof. W. B. Gregory, M.E., Tulane University, of their investigations made during 1909, and also upon data furnished by C. W. Okey, assistant drainage engineer, who continued the work of this Office during 1910 in Southern Louisiana. All quotations not otherwise credited are from the foregoing mentioned reports, the portions referring to pumping equipment being by Professor Gregory and the rest by Mr. Shaw.

<sup>1</sup> For a discussion of these soils, see U. S. Dept. Agr., Field Operations of the Bureau of Soils, 1903, p. 439.

<sup>2</sup> Louisiana Stas. Rpt. Geology and Agriculture, Pt. IV, p. 263.



FIG. 2.—WILLAWOOD PLANTATION, ST. CHARLES PARISH, LA., SHOWING PUMPING PLANT AND MAIN RESERVOIR, WITH LEVEE ON RIGHT BANK

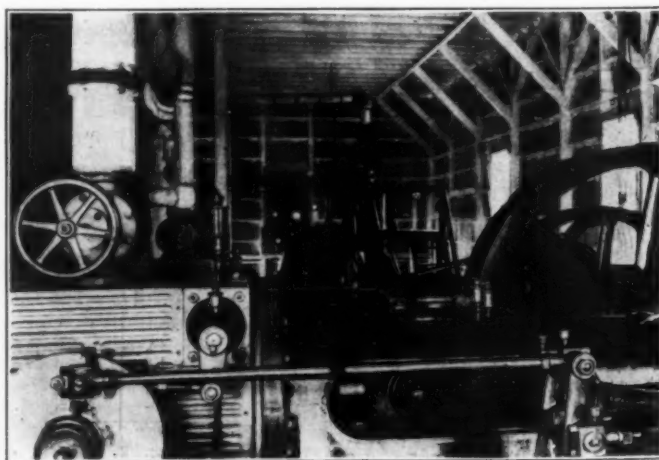


FIG. 3.—INTERIOR VIEW OF PUMPING PLANT, WILLAWOOD PLANTATION, ST. CHARLES PARISH, LA., SHOWING ARRANGEMENT OF MACHINERY

outlets have not inaptly been styled distributaries."

The water in breaking over the banks and spreading over the marshes in sheets was gradually lessened in velocity, thus gradually dropping its load of sand and silt and causing a delicate gradation of soil texture to the finest river silt far out in the marshes. These natural levees and those that have been constructed, and the improved methods of closing crevasses in the levees, have reduced the danger from general overflows to a minimum; and whereas this has prevented much damage which would be caused by the cutting out of new channels and the destruction of much valuable property, it has also checked the building up of the lowlands and their natural conversion from marshes to well-drained fields. Thus it is that nature has forced upon man the necessity of exercising his ingenuity and labor in wresting these productive lands from their water-ridden state, even as centuries ago the brave and industrious Hollanders wrested their empire from the sea.

Many of the streams and bayous now isolated have served in times past as mouths of the Mississippi or as overflow outlets in times of flood, and they have been instrumental in the distribution of the rich silt-laden waters and in the gradual advance of the coast line.

"Even before the construction of the artificial levee system, there was no raising of the general level of the marshes during periods of normal flow, and probably little sedimentation of the river bed excepting at its mouth, the most of the material which was carried in suspension to the lower portion of the river being carried out and deposited in the Gulf. As the river rose, however, the waters constantly sought additional outlets through the various bayous of the delta country. At times of extreme high water there was a general breaking over the banks of the river and its outlets. It is probable that the most of the building up of the lands above sea level has been done at such times."

The fact of the silt-bearing capacity of water being directly dependent upon the velocity is clearly demonstrated by observing the natural embankments formed by streams of various sizes. In the case of smaller streams when the water overflows, its force is soon spent and the silt is quickly deposited near the stream, forming narrow ridges with steep side slopes, while those formed by large streams are broad with slight slopes. Three typical examples, showing this difference and the manner in which the land surface has been raised on the marshes, are given in Fig. 1, A, B, and C.

The sections were taken as follows:

"A—From the right bank of the Mississippi River across the Willwood plantation, about ten miles above New Orleans. This section is about two miles long and a part of the lands crossed has been under cultivation for a great many years, while those farthest from the river were reclaimed only twelve or fifteen years ago.

The lowering of the surface of the cultivated and drained fields due to the shrinkage of humus soils is here well illustrated. There are many examples of highlands having been built up for much greater distances from the river than this, but as such accretions are indirect, on account of being formed by a number of small bayous or temporarily contracted areas of overflow which assisted in maintaining the velocity, these have not been considered as being typical.

"B—The right bank of Bayou La Fourche at Lockport, extending back through the village of Lockport and the lands of the Smithport Planting Company to Lake Fields. Until 1903, Bayou La Fourche served as an overflow outlet for the Mississippi River, the opening at Donaldsonville not having been permanently closed until that year.

"C—This is a very small bayou running through the lands of Dr. I. D. Fay, about four miles west of Lockport. The abrupt rise of the ridge from the sur-

rounding marshes is especially noticeable, and is characteristic of smaller bayous.

"Important exceptions to the foregoing general statement as to the relation between the size of bayous and the ridges built by them are frequently found.

From the foregoing discussion it is seen that these lands may not in general be drained through gravity outlets in the ordinary way, but that it is necessary to surround them by levees or embankments, and then, by the construction of an interior drainage system



FIG. 6.—MODERN PUMPING PLANT AT LA BRANCH, ST. CHARLES PARISH, LA., SHOWING OUTLET CANAL AND DISCHARGE FROM PUMPS

Prominent among those are the Bayou l'Ourse, in the southeastern part of La Fourche Parish, and the Wax and Little Wax Bayous, in St. Mary Parish. Bayou l'Ourse is an insignificant stream, occupying the center of a long and important ridge. It is probable that at one time this bayou served as an outlet for the La Fourche or possibly of some predecessor of the latter bayou, draining in a more easterly direction through Bayou Blue, Lake Fields, and Long Lake. Wax and Little Wax Bayous are streams of

ditches, lead the drainage water to some convenient point from which it is pumped over the embankment into the adjacent stream or bayou.

#### PURPOSE OF INVESTIGATIONS.

The development of these lands is now progressing with such rapidity that the United States Department of Agriculture, through drainage investigations of the Office of Experiment Stations, decided in the spring of 1909 to make a study of the conditions entering into the reclamation of these most valuable lands.

The engineers making the investigation were charged to determine the volume of water, or percentage of the rainfall, which it is necessary to pump from the fields in order to secure adequate drainage of these soils; the area of the field surface occupied by ditches, and the depth, width, and arrangement of the ditches and the levees required in a drainage system; the influence of bad physical condition of ditches upon the efficiency of the system; the distance from the ground surface at which the water table should be maintained; the difference in the level of the water in the ditches while the pumps were in operation; the percentage of saturation or the quantity of water which the soil should contain when in the best condition for growing crops.

Accordingly, four reclaimed tracts of land were chosen in the vicinity of New Orleans, which were regarded as having good ditch systems, coupled with ample pumping capacities, and, as practically no information was extant as to the relation of rainfall to the resulting run-off from these lands, rain gages were established on each tract and continuous rainfall records kept, in order to compare them with the pumping records for the same period.

The following gives a brief description of the tracts in question, including their pumping machinery equipment, and also describes a new tract, District No. 3, which is being reclaimed.

#### DESCRIPTION OF EXPERIMENTAL TRACTS.

##### Willwood Plantation—2,400 Acres.

The plantation fronts on the Mississippi about ten miles above New Orleans, and is crossed by the Southern Pacific Railway. The tract was enlarged twelve years ago, necessitating the digging of new canals and the replacing of the old wheel pump by an up-to-date pumping plant. Sugar cane is grown principally, but some corn and cowpeas are also raised,



FIG. 7.—OUTLET CANAL ON A LARGE SUGAR PLANTATION IN SOUTHERN LOUISIANA, SHOWING IT COMPLETELY FILLED WITH WATER HYACINTHS

erosion rather than of sedimentation and have been formed wholly or in part by the action of storms and the tidal flow, which is quite strong along this portion of the coast. As a result, the bayous are bordered by the marsh or by very low ridges. Both streams are from ten to fifty feet in depth and 100 to 200 feet in width."



FIG. 4.—TYPICAL WET PRAIRIE SCENE, SHOWING WILD GRASSES. DISTRICT NO. 2, NEAR RACELAND, LA FOURCHE PARISH, LA.

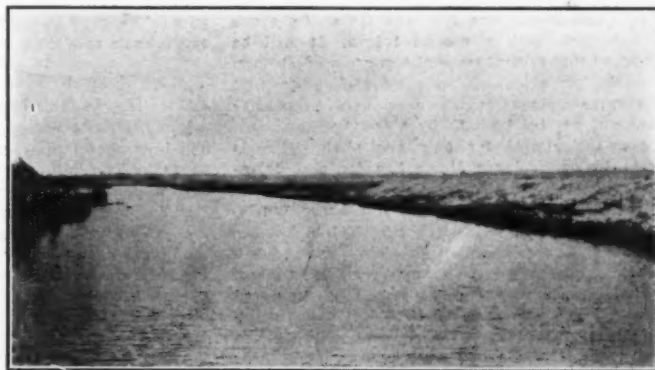


FIG. 5.—DISTRICT NO. 2, NEAR RACELAND, LA FOURCHE PARISH, LA., AFTER RECLAMATION, SHOWING BAYOU FALSE, USED AS AN OUTLET FOR THESE LANDS, WITH LEVEE ON RIGHT BANK

cultivation having taken place for a number of years. Steam for the three following pumping units is furnished by two water-tube boilers and one return tubular boiler, crude oil for fuel and a feed water heater being used.

(1) One 40,000 gallons per minute maximum capacity rotary chamber-wheel pump, rope driven from a 16 by 24 automatic, non-condensing engine.

(2) One 42-inch by 16-inch Menge pump, connected by a rope drive and a bevel gear to a 16 by 24 automatic, non-condensing engine.

(3) One centrifugal pump with 35-inch diameter discharge pipe, direct-connected to a double vertical engine.

"Pumps 1 and 2 discharge into open flumes at an average head on pump of about ten feet, which is about five feet greater than is necessary. Pump 3 has a siphon on the discharge pipe, but the end is not always submerged."

The pumping plant, with the main reservoir leading to it, is illustrated in Fig. 2, while Fig. 3 gives an interior view of the pumping plant. The direct-connected centrifugal pump appears in the background.

Smithport Planting Company Tract—647 Acres.

This tract, adjoining the village of Lockport, La Fourche Parish, has been recently reclaimed, a large portion of it from Fields Lake. Although it is all drained by well-made lateral ditches placed 200 feet apart, but a small part was put under cultivation previous to 1909. The tract is well shaped and one well adapted to a regular layout of ditches. In this respect it has the advantage of either of the other two plantations.

The pumping plant consists of two Menge pumps with impellers of 32 inches by 12 inches and 24 inches by 8 inches, running, respectively, at 230 and 330 revolutions per minute. Each pump is rope driven by a slide-valve non-condensing engine, while steam is supplied by a 100-horse-power return tubular boiler, no feed water heater being used.

District No. 2—940 Acres.

Located five miles west of the village of Raceland, La Fourche Parish, this plantation is as yet only partly under cultivation and the system of ditches is not complete. On account of a very thick top layer of humus of only partly decayed vegetation, good drainage is secured with lateral drains spaced several hundred feet apart instead of at distances as shown on the map (Fig. 4).

Two 32-inch by 12-inch Menge pumps are used, one belt driven, and the other rope driven by two 12 by 16 slide-valve non-condensing engines. Two 60 horse-power locomotive-type boilers furnish the steam.

Fig. 4, a typical marsh scene, shows the wild grasses common to this section. It is a view of a portion of District No. 2 before reclamation. Fig. 5 gives a view of the same district after reclamation, showing the levee as constructed, and also Bayou False, which serves as an outlet for these lands as well as for the new tract adjoining them, which is described later.

Fig. 6 is an excellent view of a modern Menge pumping installation at La Branch, La. It is very similar to that installed for District No. 2 near Raceland.

New Orleans Land Company Tract—1,380 Acres.

Although inside the city limits of New Orleans, this tract has but recently been inclosed by protection levees. Originally heavily timbered with cypress and gum, there are still many of the small trees standing, and thus far only a few main canals have been dug. These canals vary in width from fourteen to forty feet, and interior lateral ditches will be constructed

later. Drainage is secured by gravity into the city sewer system, and thus this tract differs from the other three in requiring no pumping installation.

District No. 3—2,400 Acres.

This is a new project lying between Raceland and Lake Fields, in La Fourche Parish, and it embraces the latest practices as to ditch arrangement and modern pumping equipment. The soil is typical turf land and the surface elevation is 3 to 6 feet above mean tide. The reservoir canals are 40 feet wide and 6 to 8 feet deep, and the collecting ditches have a bottom width of 2½ to 3 feet and a depth of 4 feet. The laterals are spaced 210 feet apart, and are made 3 feet deep, with bottom widths of 1½ to 2 feet. The pumping equipment consists of two 30-inch Lawrence centrifugal pumps discharging under water, so that the lift varies between 2½ and 5 feet, according to the stage of water in Bayou False, which takes the discharge. Direct-connected to the pumps are two 100 horse-power vertical engines, steam being supplied by two locomotive-type boilers.

#### MEASUREMENTS OF RAINFALL AND RUN-OFF.

"The calculations of run-off were made from the logs kept at the various pumping plants, each pump having previously been rated. Most of the discharge flumes are rectangular in section and open at the top, permitting the use of weirs for making measurements of the water pumped. These measurements were simplified by the fact that each pumping unit was equipped with a separate discharge flume. Pumps discharging through pipes were rated by means of a Pitot tube.

"The run-off from the New Orleans Land Company tract was obtained by means of weir measurements. A 4-foot weir is placed in the main ditch and discharges into a flume, which in turn empties into the drainage canal leading to city drainage station No. 7. The weir and flume are covered by a small tent house in which is located a recording gage or water register. The cross section of the canal is large back of the weir, insuring complete contraction, so that the measurements are unusually accurate, and the Francis weir formula applies. Two rain gages are now located on different sides of the tract and the mean of the records is used in calculations of rainfall."

Records were kept continuously from June 1st, 1909, to January 1st, 1910, with the exception of those of the New Orleans Land Company tract. These latter started June 16th, but were interrupted on September 20th, 1909, by a breaking of the city levees, and the consequent shutting down of the city's pumping plants, due to the severest hurricane known to this section sweeping in from the Gulf of Mexico. Backwater from Lake Pontchartrain and the accumulation of the city drainage water prevented normal conditions from being established till October 9th, when the records were continued.

As the investigations cover such a short period of time, care must be exercised in making deductions from the results. The records are still being continued, however, so that more reliable conclusions can be made at some later time.

During August the pumps in District No. 2 were operated on ten days, although the actual amount of run-off was small. This was due to the fact that it was desired to maintain a certain stage of water to insure the successful operation of a hydraulic dredge which was engaged in clearing and deepening the reservoir canal.

"The data which have been collected would indicate that a much greater run-off may be expected from the better ditched and fully cultivated lands than from those that are more nearly in a natural state. While this may be true, it is probable that a long series of

uninterrupted records will show a less striking variation. The records on the New Orleans Land Company tract did not begin until the effects of a 5-inch rainfall of the first part of June had passed and they were suspended during and after the severe storm of September 20th, thus not including the heaviest storms of the season, with the exception of that of December, when the rainfall was heavy and mostly fell in a few hours' time, thus giving the largest percentage of run-off of any recorded. The decreased evaporation of December no doubt also increased the run-off."

Owing to the fact that at times of extreme high water a few acres are drained by gravity on the Willows plantation, it is probable that the run-off records for that tract show a slightly less quantity than they should.

The fact is well known that very heavy storms cause a larger percentage of run-off than smaller ones, but for storms of all magnitudes there is a variation in the ratio of run-off to rainfall, due to the varying conditions of the soil and to its character and state of moisture, the duration of the storm, amount of evaporation and seepage, slope of ditches and fields, and arrangement and capacity of reservoirs, manner of pumping, and probably to other causes not yet determined.

"Excepting as affected for short periods by rains and by pumping, the height of water in the reservoir canals represents fairly accurately the height of ground water of the lower lands. This is notably true of the Willows tract, where the lowlands are porous and allow a quick adjustment of water level following a change in level in the canals. As an indication of the effect of evaporation, including the transpiration of the vegetation, the record for the month of July is especially interesting. The month was begun with the soil well moistened by showers late in June, yet, with a precipitation of 1.17 inches from July 1st to 19th, there was a rise of only 2½ inches in the reservoir, while from July 5th to 19th, with a precipitation of 0.99 inch, there was an actual lowering of the water level in the canal."

A few records of pumping operations are available, but the lack of essential details makes them of little value for the purpose of the calculation of run-off. An approximate idea can be gained, however, as to the amount of pumping necessary in order to maintain the water table at the proper height for profitable cultivation. A daily pumping record of the Willows plantation for 1907 and 1908 has been compiled by Mr. Shaw from the diary of the engineer in charge of the pumping plant. Comparing the two years, it is found that during 1907 it took 14.8 hours' pumping for each inch of the 66.32 inches of rainfall, whereas in 1908 the pumps ran 12.9 hours per inch for the 51.06 inches of rainfall in that year. This on its face would seem to indicate that the uneven distribution of the rainfall throughout the year, as well as the fact that one part of the plantation may receive a very heavy precipitation during certain storms, while only a small shower may affect the rest of the land, has but slight effect on the general yearly average, and that year by year the ratio of the necessary pumping to the rainfall will be fairly constant.

"The mean annual rainfall at New Orleans amounts to 57 inches. There is a slight increase in precipitation in the extreme southeastern part of the State, while it drops off to about 50 inches at Cameron, which is in the western part near the Gulf coast. At Shreveport, about 200 miles from the Gulf of Mexico, the average precipitation is 46 inches.

(To be continued.)

### The Mercadier System of Multiplex Telegraphy

THE new Mercadier system of multiplex telegraphy showed very good results in tests which were made between Paris and Lyons not long since. Only one wire was used, with a ground return. It will be remembered that several transmitters are used at once, each producing a wave of a certain pitch, so that all the waves are sent at once over the wire, and are selected out at the far end by vibrating diaphragm selectors, each tuned for only one pitch. Signals are sent by an ordinary Morse key for each transmitter. Professor Mercadier adapts it specially to rapid printing telegraphs, Baudot, Hughes or Wheatstone or Morse registers, such as are used in Europe. In the Paris-Lyons experiments there was used a quadruple Baudot printing telegraph working on direct current. In addition to this there was connected the Mercadier apparatus applied to six Hughes printing telegraphs. Wave currents were used here on the wire, but the Mercadier relays translated these into direct current signals with local batteries, so that the printing telegraphs could be thus operated. In this way the quadruple Baudot printers worked

with direct current on the live wire, while the same wire carried six kinds of vibratory current, each sending its own message to one of the six Hughes printers. This greatly increases the capacity of the wire. The new apparatus is designed so that it is very simple and is easily worked.

### French Studies of Insecticides

WE already had occasion to mention some researches made in France upon applying insecticides to plants, and it is shown that special attention must be given so as to have a liquid which will wet the surfaces, such as insects, etc., properly, in order to be effective. For use upon leaves of plants this is also true, as the proper wetting increases the adherence, and it thus favors the penetration of active matter such as copper salts into the leaves. For insoluble substances such as arsenate of lead or copper, capillary attraction gives a closer adherence, and this is more durable. More recently, M. G. Gastine shows that the wetting can be obtained not only with soaps, but also with the saponines, which are better than alkaline soaps, as they are not decomposed or precipitated by certain bodies, so that they can be used

where soluble soaps cannot be employed. Numerous plants contain saponines, such as Quillaya, Saponaria, Nielle and others. An alcohol solution of Quillaya has been used for making emulsions of medicinal substances like resins or balms. But there is an Algerian fruit which contains a large amount of saponine, and this is the Sapindus, a tree cultivated for a long time past. The fleshy part of the fruit has over 50 per cent of a saponine which is very soluble in water and alcohol. Insecticide liquids can be made of it which give a very good adherence, also emulsions can be made without needing alcohol, and these are very stable. The author prepared specially different emulsions of tar oils or crude petroleum. These oils are officially prescribed in Italy for use in destroying an insect of the small cochineal kind which is of Japanese origin and is very dangerous (*Diaspis pentagona*). It attacks fruit trees of different kinds, and also flowering plants. In winter there are applied 7 per cent emulsions of tar oils or crude oil, so as to act on the adult female insect, which is well protected and hard to penetrate. The young insects are easily killed by 2 per cent emulsions. However, in spite of the fact that salt solution is

used so as to bring the density near that of the oil, and flour is added to flavor the emulsion, such products are unstable, and if not well shaken the oil separates out quickly. The oil, however, will destroy the buds of the plants. Soaps will give stable emulsions, but it was found in Italy that these could not be used,

as the soaps lessen the poisonous action of the oils. The author made good emulsions with Quillaya and Saponaria, etc., but the Algerian fruit is especially good. A small quantity of the powder will emulsify a large amount of tar oil, and the emulsion is so fine that it passes through filter paper. Under the

microscope it resembles milk. Copper salts can be added to tar oil and crude oil emulsions, and this is excellent for use against the above insects, and also Aphides as well as parasite growths. Water, 10 liters; sopindus powder, 20 grammes; neutral acetate of copper, 100 grammes.

## Eugenics and Genetics\*

### "Good Breeding" and Its Significance

By G. Clarke Nuttall

THE terms are new—the problems they stand for are as old as Cain and Abel. And yet it is well that the nomenclature should be of to-day, for these terms represent the points of attack at which we of the present, with the latest weapons of modernity, are attempting to storm the hitherto impregnable strongholds of the mysterious heritage of the children of men.

From the beginning of time such questions as to why the son is like and yet unlike the father, why and how it comes about he may have, say, his father's hair with his mother's eyes, and the character and personality of a great-uncle, or, yet more puzzling, why in a family marked by a strong unity of characterization one child may be strikingly dissimilar to all the rest, have forced themselves with bewildering fascination upon all who have stood aside to consider for a moment our common humanity; while the deeper problems of the inheritance of moral traits and defects and within what limits, moving among hereditary influences, free will can act, are points that have pressed upon the thinkers of mankind with an almost unbearable burden. Hence this present generation, with its mind set on keen scientific inquiry, was necessarily bound to approach this illimitable field of research into which explorers have as yet pierced so short a distance, and it is interesting to note the two chief roads by which it is setting out in its quest, the one road being known as the Eugenic, and the other as the Genetic.

Now, Eugenics (literally "good breeding")—a term already familiar enough among a small and select school of thought but practically unknown to the commonality at large—is defined as "the study of agencies under social control that may improve or impair the racial qualities of the future generations either physically or mentally." It is the science which deals with all the influences that tend to improve the inborn qualities of a race, and its aim is to influence by every possible means the useful, the sane, in the fullest connotation of both mental and physical health—in a word, the best classes in the community—to contribute more than their proportion to the next generation, and, incidentally, of course, to discourage in every way the degenerate, the unfit, from perpetuating their weaknesses. Obviously, then, there is in Eugenics, in addition to the ordinary study of the well-worn problems of heredity, a large ethical element, and it is this element, this definite appeal to the common conscience to bring moral laws into a sphere hitherto singularly outside of them, that stamps this science with the impress of to-day. It is this feature that is the special product of our time, and we owe its inception to the genius of that veteran student of human problems—Francis Galton.

Genetics, on the other hand, contains no element of ethics, *per se*, within it, for it is purely an inquiry into the physiology of heredity and variation. It examines the ultimate physical elements of life; it records processes; it seeks to discover and tabulate the laws that govern them. Good, bad and indifferent stocks are all alike in its eyes, for all afford suitable material for research to the student of this science. Genetics merely cares how things *as they are* happen, it carries no ideal other than the acquisition of knowledge before it. Therefore, while the aim of Eugenics is the realization of an ideal in the future, the aim of Genetics is pure knowledge of facts in the present. Genetics, therefore, is the handmaid of Eugenics, for the Eugenist will take the facts that Genetics provides and use them in the furtherance of his aims. Curiously enough, while Eugenics is the child of a living scientist, the source of inspiration of recent Genetics is a dead monk—the Abbot Mendel of Brno. He, working in his monastery garden fifty years ago, was dead and forgotten for twenty years before his writings were found, but then so instinct with vitality were they that they had only to be placed in suitable soil for a veritable tree of knowledge, a new science, to spring from the tiny grain he had planted so unobtrusively many years before.

Both Eugenics and Genetics exhibit phases of novelty hitherto undreamt of and react one upon the other. Genetics has presented startlingly new conceptions before us, and has brought into discussion

facts that had become practically axiomatic in their acceptance, while Eugenics has placed in the moral sphere considerations that have hitherto been received as "nature," and therefore not to be questioned. Let us then pass in review some of these phases.

Now it is absolutely amazing how callous the social conscience of the ordinary person has become upon the moral issues raised by Eugenics. Even the most flagrant transgressions are condoned. The following anecdote is but a sample of general experience. The present writer had occasion to visit at times a small house where the door was always opened by a little household drudge of the poorest description. A dwarf, of poor mentality, her lack of intelligence had a peculiar weirdness given it by an appalling squint. One day she was missing, and an inquiry after "Eliza" elicited the surprising information that she was married. An expression of dismay was met by the retort from her acquiescent mistress, "That it really did not matter, for he was no better than she." "He" proved to be a weak-minded youth who could just earn a scanty wage of 10s. a week by blowing a church organ. By this time indignation was boiling over, and a forcible remark on the iniquity of the mistress allowing such a marriage was met by the offended retort that "It couldn't in no way be wrong, for they were married in church." And that was the last word. What more could one say? Not only are such marriages sanctioned by our common morality, but they have actually the blessing of God called down upon them by His appointed minister! And yet there is not one decent-minded person who, if he will but stop and think it over, does not turn in disgust from the very idea of such a marriage.

It is to meet cases like this—better and worse—and many similar problems, that the Eugenist is setting himself to work, for he has been converted to the fact that the law of inheritance is as inevitable as the law of gravity, and, moreover, that psychical characters are inherited just as surely as physical. A notable work in driving this fact home has been done of late by Karl Pearson, who examined a large number of children from the point of view of both physical and psychical characteristics. Thus on one side they were scrutinized as to their heritage for health, eye color, curliness of hair, cephalic index, head length, head breadth, etc., and on the other side for vivacity, assertiveness, introspection; popularity, conscientiousness, and the general conclusion arrived at was that both physical and psychical characters in man are inherited (within broad limits) in the same manner and with the same intensity. Again, with regard to insanity and pathological defects generally the same rule holds good—they are inherited in precisely the same manner as are the physical and psychical characters.

Now, since we are shown to inherit our parents' conscientiousness, shyness and ability, even as we inherit their stature, forearm and span, the Eugenist goes a step further and points out that, when we come to the bedrock of things, all moral health, like physical health, all goodness, probity, capacity and the like, together with eyes and hair and stature, are an inheritance—"Bred, not created." "A question of breeding, not pedagogics." Of course, if the germs are there to begin with, they can be quickened by religion, encouraged by environment, and directed by all the wonderful resources of education; moreover, the will is free to stimulate or stifle as the man desires, but nevertheless the main contention is that no amount of moral effort, no excellence in teaching, will evolve what is not there—"The creature is not made, but born."

Since qualities (or no-qualities-at-all) of the intellect come under the same ruling, the Eugenist challenges some of the latest of our philanthropic movements. For instance, the efforts now being made to deal with the slightly deficient—both morally and mentally—the attempt to screw them up to the normal and keep them there—heart-breaking work for all engaged upon it—is work which, it is pointed out, is not only useless, but positively harmful. In the past the weak and unfit were allowed to go to the wall, trampled out of existence; the lunatic treated

as a criminal, and the survival of the fittest was the only law. Then came a revulsion against the cruelty and unreason of it all, a higher ethical standard was set, the law of kindness asserted itself, and the weak, the unfit, the insane, were protected; but the movement went too far—it "o'erleaps itself and falls on the other side," for it began to form classes under specially trained teachers with the express object of dragging up the feeble people so that they could enter on better terms in the race of life, enter but, alas! never truly compete, for, from the outset, they are foredoomed to ultimate failure, and the course has been strewn with the ill-starred wreckage. NO—the Eugenist insists that the weak and defective are not to be dealt with in such a way that for the few best years of their lives when their capacities are at their highest, they may be able to lag along not too remotely behind the average folk and thus earn a pittance, and, meanwhile, incidentally leave a legacy of equally unhealthy, equally deficient children to the nation. These classes, this philanthropy, is socially unsound and immoral if that is what it does. "Pity and help the weak, but remember that it is a national evil when any charitable or social institution allows the indefinite multiplication of the unfit in mind and body," says Major Leonard Darwin. Instead, the Eugenist urges, these efforts should simply aim at separating out of the vast number of school children those who are distinctly below the normal in intelligence, distinctly lacking in moral sense, and after careful consideration over a period of time place those judged undesirable on one side, saying, "The strain from these poor children shall never vitiate the stream of our national life; the degeneracy, the pollution they exhibit shall, as far as they are concerned, die with them. They shall not be treated as if they were responsible for their deficiencies; their lives shall be made happy, but they shall run under definite discipline and within definite bounds; they shall have, as it were, the freedom of a large and pleasant garden which is, however, shut off from the outer world by an impregnable fence." In several parts of the country the Eugenic spirit is providing little homes upon these lines. In one recently visited by the writer there were about a dozen girls, all of whom were defective, and yet not one of whom was bad enough for an asylum. In an ordinary way such a girl would have lived at home supported or half-starved, as the case might be, the drudge of the house, the butt of those around, a trouble to relatives, a misery to herself, with the almost inevitable result of eventually landing in the maternity ward of the workhouse, and another child brought into the world to carry on the heritage of misery, sin and defectiveness. But here, in Sunny-side, they were in a happy home with simple tasks and games, cheerful pictures and the simplest but brightest surroundings, all directed by a firm but kindly matron—prisoners, indeed, in one sense, but prisoners with no sense of bondage, no desire for freedom. And the State is the gainer for the lopping off of a diseased limb from the community. The poison flow is checked.

It is confidently asserted that feeble-mindedness could be practically stamped out in two generations if the State rigorously determined to check the perennial flow of the strain of the unfit into our national life. The cost of establishing homes for the feeble-minded throughout the country is often demurred to, but, granted that it is great, would it not pay a hundredfold in the end? And, indeed, it is rather a rearrangement than an increase of expenditure that is needed, for practically all these cases come upon the Poor Rates in the long run, when parents or relatives die. They cannot support themselves, and there is, in addition, the double heritage from those years of freedom of children to follow their parents, for "on an average each degenerate has one child as degenerate as himself or herself, and others in whom the taint is latent but liable to appear in a succeeding generation." The taint of degeneracy in our population is now alarmingly great, and threatens to increase indefinitely under our present policy of encouraging the unfit. So that the Eugenic Education Society, lately formed to call attention to this most

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pressing question, is in the forefront of reform movements of the day in attempting to meet that great need as set plainly forth in the report of the Physical Deterioration Committee, when, in 1904, it stated: "The committee are impressed with the conviction that some general educative impulse is in request which shall bring home to the community at large the gravity of the issue, i. e., physical deterioration, and the extent to which it is within individual effort to promote and make effective the conclusions of expert opinion."

One thing is certain, the ordinary man and woman of to-day is in a fool's paradise with regard to this question. They contentedly pass it by as not concerning them at all, "as not quite 'nice'" for their consideration. And yet at this moment our country is at a most critical time. It is an open secret that the intellectually strong, the best of our national life, are not adding their full quota to posterity; they hang back from the responsibility; they shrink from the pressure of adjusting ways and means. "For the last forty years," says a student of the subject, "the intellectual classes of the nation, enervated by wealth or by love of pleasure, or following an erroneous standard of life, have ceased to give us a due proportion of the men we want to carry on the ever-growing work of our empire, to battle in the forefronts of the ever-intensified struggle of nations." On the other hand, the degenerates, the feeble, the hangers-on of the strong, fostered by false sentiment, are adding more than their due share, thus intensifying the discrepancy, and—"The ultimate result is in no doubt. We have two groups in the community, one parasitic to the other. The latter thinks of tomorrow and is childless, the former takes no thought and multiplies. It can only end as the case so often ends, the parasite will kill its host, and so ends the tale for both alike."

If then Eugenics, the influencing of the hereditary forces that are molding our national life, is to-day of such primary importance, all knowledge which can help in this great work is of no less importance, as has already been pointed out, and Genetics is far and away its most serviceable handmaid. In a sense, Genetics represents the material side of the question; it attempts to show precisely *how* powers and faculties are transmitted, what cells are engaged, what physical elements carry the inheritable properties from generation to generation.

Already Mendelian—and Genetics to-day is largely Mendelian in its lines of work—has brought some striking facts to our knowledge. For instance, it has absolutely revolutionized our idea of what is known as "pure-bred." Now, in pre-Mendelian days our conception of a "pure-bred" individual was one who was descended from a long line of ancestors, all of whom were of the same type, and as a consequence of which the individual in question more or less nearly approached it. But now we know that purity of type in no way essentially depends upon continued selection. In certain cases a "pure-bred" individual may result from parents both of whom are "cross-bred"—which is a paradox; and, moreover, that the descendants of these individuals will be absolutely "pure-bred" henceforward for all time as long as no new element is introduced later. How this can happen must be sought for in that wonderful discovery of the segregation of gametes which is Mendel's priceless legacy to the world. It is not the place in this short paper to go into the technicalities of Mendelian hypothesis, but the underlying idea may be roughly summarized as follows:

Each individual is made up of a large number of distinct characters contributed from two sources, i. e., from its two parents, in respect to any of which he may have received two similar portions or two dissimilar portions, one from each parent. But one or other of the parents may be lacking in some of the characters, in which case he will receive a character from one parent, and nothing corresponding to it from the other, either like or unlike. Further, to use an Irishman, any particular character may be absent in both parents, and therefore necessarily represented in the offspring also by its absence. Now, the offspring will be "pure-bred" for any character, if it receives it alike from both parents or does not receive it at all; it will be "cross-bred" if it receives it unlike from both parents or receives it only from one parent, and not from the other. "If neither parent possesses a certain factor at all, then none of the offspring will have it; if both parents have it, then all the children will have it; if one parent has it and the other has not, then on an average half the family will have it and half be without it."

A second most important fact that Mendelism has lately pointed out is that it is in the second generation from the parent—the grandchildren, so to speak—in which we must look for the possibilities that may result from cross-breeding. There all types possible from that particular cross will be found. It has been ignorance of this law that has been chiefly

responsible in the past for the disappointments of breeders of both animals and plants.

Again, all sorts of interesting side-lights are being thrown upon our knowledge of biology, such as, for instance, that in the flowers of certain stocks the pollen—the male element—is all of one type, while the egg cells—the female element—carry either the quality of doubleness or that of singleness. Then, too, in the question of the nature of sex the interesting suggestion is now put forward that the quality of "femaleness" is a definite Mendelian factor following ordinary Mendelian rules, while "maleness" is a condition due to the absence of this quality.

Although, so far, Genetic conclusions have been principally based upon research confined to the realms of plants and the lower animals, owing to the difficulty of treating human subjects, and the length of time observation required in their cases, yet sundry successful excursions have been made into human affairs, and the descent of certain abnormalities and defects has been brought under law. Of the law of transmission of normal qualities little is yet proved or, in fact, attempted. Eye coloration is one quality, however, that has recently been successfully dealt with. Here it has been shown that parents whose eyes are without any brown pigment at all, i. e., blue or gray eyes, can only hand on to their children blue or gray eyes, while those parents who have any brown pigment in their eyes may hand on to their children both brown eyes and eyes without it, namely, blue or gray. But even if progress has not yet gone far, at any rate sufficient has been done to show that man can control his heritage far more effectually than he dared once to suppose.

The Eugenists and the Mendelians do not, in these early days, always see eye to eye in their statistics or in the whole of their policy. Thus Prof. Bateson, one of the leading Mendelians of the day, believes that "while the elimination of the hopelessly unfit is a reasonable and prudent policy for society to adopt, any attempt to distinguish certain strains as superior, and to give special encouragement to them, would probably fail to accomplish the object proposed, and must certainly be unsafe"; and referring to some of the Eugenic ideas already set forth earlier in this article, he continues, "Their proposals are directed in the belief that society is more likely to accept a positive plan for the encouragement of the fit than negative interference for the restraint of the unfit. Genetic science . . . gives no clear sanction to these proposals." Still he joins issue with them in that "Some serious physical and mental defects, almost certainly also some morbid diatheses, and some of the forms of vice and criminality could be eradicated if society so determined." And that "Genetic science must certainly lead to new conceptions of justice."

But in the present embryo state of both Eugenics and Genetics unanimity is not to be expected, and definite dogma is impossible and indeed undesirable. But the upshot of the whole matter at the present time is that Genetics is working—and apparently along successful lines—to bring law and order into the inchoate mass of the facts of heredity, while Eugenics is striving to lead man to use his conscience as well as his intellect in dealing with his knowledge.

#### A Great German Barrage

THERE is being built in Germany a great barrage which forms a storage lake of very extended area, in order to supply the new Rhine-Weser canal, especially the section of the canal leading from the Ems to the Weser stream. However, as the canal takes a large supply from the Weser, and it is desired not to interfere with navigation on the stream on that account, an extra supply is needed so as to come into use to bring up the level of the Weser during low water stage, and give the needed flow for the canal. A great barrage is to be erected across the valley of the Eder, so as to store up the water due to the winter freshets of this latter stream. It is known as the Waldeck Barrage, and the artificial lake thus formed will drain off a basin of over 14,000 square kilometers (5,405 square miles). The lake will extend for about fifteen miles above the barrage. Three villages will disappear, and will be submerged under the lake. Its surface will be 1,200 hectares (2,965 acres), and it will contain no less than 202,000,000 cubic meters (264,195,800 cubic yards). The retaining wall is to be 48.6 meters above foundations, and is built of stone. On the upstream side there will be a protecting sole of reinforced concrete, in order to prevent leakage of water under the dam. The concrete work will go down below bed rock, and thus cover over the junction of the dam with the rock bottom. On the same side there will be applied a three-foot clay flooring over the surface of the valley for a distance of 100 feet. The total volume of the masonry work is 300,000 cubic meters (392,370 cubic yards), and the cost of the work is estimated at \$5,500,000 at a low estimate.

#### Engineering Notes

It is planned to use about 70,000 horse-power in two large hydraulic plants which are to be erected in the South of Switzerland, not far from the Italian frontier. This will rank among the large power plant enterprises in Europe. It will be remembered that the great Brusio hydraulic plant is located in this region. A Swiss company is planning the work, and it is proposed to use the Landwasser and Albula streams, with the turbine stations erected at Filisur and Bergun.

**Separation of Oil from Condenser Water by Electrolysis.**—The condenser water of steam engines always contains more or less lubricating oil, which is too valuable to be thrown away. This oil can be recovered by the Davis-Perret process, in which the very stable emulsion which the oil forms with the water is electrolyzed, with iron electrodes, after the addition of sodium carbonate. In these conditions a basic iron salt is formed, which envelops and precipitates the oil globules, which are then removed by filtration. Ellis finds that the addition of colloidal oxide of iron to the condenser water produces the same result. The Davis-Perret separator is useful for clarifying all liquids which are turbid owing to the presence of colloidal or emulsified substances.

**Farm Engines.**—The agricultural commission of the French Automobile Club holds a concours every six years, and gives prizes to cultivators who make the best use of gasoline motors for farm work. It is especially desired to encourage small plants which are mounted by the farmer himself and show an ingenious use of the motors. M. Yvonne-Thovareck received the first prize for a very well designed plant where a 1½ horse-power motor can drive no less than nine farm devices, such as straw cutter, root cutter, crusher, grindstone, circular saw, well pump, besides various dairy machines. All these are in the same building and are belted to different countershafts. This gives him \$600 yearly saving. M. Thiebaut uses a second-hand tricycle motor for a threshing and other devices. For plants of this kind the commission awarded sixteen medals or cash prizes.

**The Art of Felling Chimneys.**—An interesting method of felling lofty chimneys is practised in England. The originator of this method, a Manchester man, is credited with having felled, without accident, more than 100 chimneys which for one reason or another had become useless. Some of these were from 200 to 250 feet in height. The method consists in removing the stones or brick near the foot of the chimney and substituting an underpinning of wood, which is afterward set on fire. About two-thirds of the area of the base is removed up to a height of 5 or 6 feet, so that most of the weight rests upon the underpinning. Experience has shown that when the work is properly done the chimney leans slightly toward the side where the underpinning is inserted, and when a slight crack appears in the masonry on the opposite side the time has come for the fire to be applied. As the chimney falls it partially telescopes in consequence of the shock produced by dropping into the void left by the burned timbers.

#### Explorations in Chaldea

COMMANDANT CHOS has been exploring the site of the ancient city of Sipprouria in Chaldea, and found remains of buildings and various objects which go back before the founding of Babylon. The part which he uncovered consists of different kinds of constructions which were of practical usefulness, such as granaries and like storehouses. Water from wells was brought to various places by culverts built of brick and went into a number of basins for industrial use. A somewhat unusual find among the storehouses was a large collection of dried fish, these being of large size. The skeletons of the fish and their scales are still to be seen. On the spot were found many stamped baked clay tablets, and among these were storehouse accounts which showed that the fish, like many other products, represented tribute paid to the King's treasury by various tribes, these being under the control of the Queen's intendant.

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